I. C. 7380 SEPTEMBER 1946

UNITED STATES
DEPARTMENT OF THE INTERIOR
J. A. KRUG, SECRETARY

BUREAU OF MINES
R. R. SAYERS, DIRECTOR

REC'D
NOV 6 - 1946
O. S. U. LIBRARY

INFORMATION CIRCULAR

SAFE STORAGE, HANDLING, AND USE OF COMMERCIAL EXPLOSIVES IN METAL MINES, NONMETALLIC MINES, AND QUARRIES

BY

D. HARRINGTON AND J. H. EAST, JR.

Generated on 2024-09-19 17:03 GMT / https://hdl.handle.net/2027/osu.32435030643852
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

I.C. 7380,
September 1946.

INFORMATION CIRCULAR

UNITED STATES DEPARTMENT OF THE INTERIOR - BUREAU OF MINES

SAFE STORAGE, HANDLING, AND USE OF COMMERCIAL EXPLOSIVES IN METAL MINES, NONMETALLIC MINES, AND QUARRIES[1]

By D. Harrington[2] and J. H. East, Jr.[3]

CONTENTS

	Page
Introduction	3
Statistics on the use of explosives	3
Definition of explosives	5
Characteristics of explosives	6
Classes of dynamites	7
Straight dynamite	7
Gelatin dynamite	7
Ammonia dynamite	7
Permissible dynamite	8
Ammonium nitrate explosives	8
Organic nitrate explosives	9
Liquid carbon dioxide	9
Liquid-oxygen explosives	9
Black blasting powder	10
Smokeless powder	12
Detonators and igniters	12
Blasting caps	13
Electric blasting caps	13
Detonating fuse	14
Igniters	14
Squibs	14
Electric squibs	14
Delay electric squibs	14
Delay electric igniters	15
Safety fuse	15
Blasting machines	15
Storage of explosives	16
Construction of magazines	16
Transportation of explosives	18
Use of explosives	20

1/ The Bureau of Mines will welcome reprinting of this paper provided the following footnote acknowledgment is used: "Reprinted from Bureau of Mines Information Circular 7380."

2/ Chief, Health and Safety Branch, Bureau of Mines, Washington, D. C.
3/ Mining engineer, Bureau of Mines, Washington, D. C.

Generated on 2024-09-19 17:05 GMT / https://hdl.handle.net/2027/osu.32435030643852
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

CONTENTS (Cont'd)

	Page
Opening explosives containers	20
Charging holes	21
Making primers	21
Safety fuse and cap blasting	22
Electric blasting	23
Use of a blasting machine or battery	24
Job training	25
Some typical blasting accidents	25
Smelter blasting accident	25
Comments	26
Failure to give warning causes an accident	26
Comments	26
Accident caused by loading a "hot" drill hole	26
Comments	27
Two accidents while capping fuse	27
Comments	27
Smoking probably causes an accident	27
Comments	28
Shaft accident caused by using short fuse	28
Comments	28
Conclusions	29
Bibliography	30
Bureau of Mines publications	30

ILLUSTRATIONS

Fig.		Following page
1.	Plan and sections of cement-mortar magazine	16
2.	Magazine of simple construction for storing small quantities of explosives	16
3.	Standard sand-filled or weak concrete-filled magazine	16
4.	Standard brick magazine	16
5.	Linings for steel magazines	16
6.	Method of constructing a sand-tray ceiling	16
7.	Method of installing sand trays and ceilings in magazines of various types	16
8.	Sketch of an easily constructed magazine door	16
9.	Magazine ventilation	16
10.	Box-type magazine for storing small quantities of explosives or those for immediate distribution	18
11.	Recommended methods for making primers with safety fuse and blasting caps	22
12.	Recommended methods for making primers with electric blasting caps	22

Generated on 2024-09-19 17:13 GMT / https://hdl.handle.net/2027/osu.32435030643852
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

INTRODUCTION

The tremendous expansion of industry during the war and the unprecedented demands for metals and minerals are reflected in the production and use of explosives during that period. The increased use of explosives brought added safety problems to industry because of the necessity of using men as blasters who were not entirely familiar with and some who were totally unfamiliar with the characteristics of some or all of the various explosives. A discussion of the characteristics of the ordinary types of explosives used in industry should assist in giving a better understanding of the hazards attending their use. Explosives are compounded so they may be used with reasonable safety provided the user understands and follows the procedure recognized as standard safety practice. Short cuts and the failure to understand and use recognized safe practices, as well as the selection of explosives unsuited for the work at hand, are all part of the safety problem.

The extent to which explosives are used in the United States is shown by a study of the statistics compiled by the Bureau of Mines[4/] regarding them. Some of these statistics are shown below and serve as an indicator of the tremendous number of men engaged in the transportation, storage, and use of explosives. These men are exposed to the inherent hazards attending this occupation and they should be familiar with the recognized safe practices relative to explosives.

STATISTICS ON THE USE OF EXPLOSIVES

The domestic production of all classes of industrial explosives in 1938 was 332,130,498 pounds, compared with the total production in 1943 of 477,650,985 pounds, and in 1944 of 464,111,323 pounds, an increase of 43.8 percent and 39.8 percent respectively. The production of industrial explosives is shown by years in table 1 and graph A.

TABLE 1. - Explosives used in industries of the United States, in pounds

Year	High explosives other than permissibles	Permissible explosives	Black blasting powder	Total
1938	238,576,242	41,859,281	51,694,975	332,130,498
1939	278,250,328	49,950,415	58,236,825	386,437,568
1940	305,179,700	58,436,130	59,753,400	423,369,230
1941	351,857,453	70,612,209	59,457,575	481,927,237
1942	359,698,547	84,022,296	55,533,750	499,254,593
1943	338,573,441	92,655,519	46,422,025	477,650,985
1944	318,613,301	102,538,247	42,959,775	464,111,323

4/ Adams, W. W., and Wrenn, V. E., Production of Industrial Explosives in the United States During the calendar Year 1942: Bureau of Mines Tech. Paper 658, 1944, 24 pp.
Adams, W. W. and Wrenn, V. E., Production of Industrial Explosives in the United States During the Calendar Year 1943: Bureau of Mines Tech. Paper 665, 1944, 26 pp.

Generated on 2024-09-19 17:02 GMT / https://hdl.handle.net/2027/osu.32435030643852
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

During the 7-year period from 1938 to 1944, inclusive, industry has made a definite change in the types and kinds of explosives used. Dynamites of various types have replaced black blasting powder to a large extent, as shown in tables 1 and 2. In 1938, black blasting powder used in industry amounted to 15.6 percent of all commercial explosives consumed in the United States, but only 9.2 percent in 1944. This change is reflected largely in the increased use of permissible explosives, which are modified dynamites used chiefly in coal mining. Permissible explosives comprised only 12.6 percent of the commercial explosives used in 1938, but 22.1 percent in 1944 (table 2). In 1944, dynamite of all types amounted to 90.8 percent of all commercial explosives used, as compared with 84.4 percent in 1938.

TABLE 2. - Percentage of total explosives used, by types

Year	High explosives other than permissibles	Permissibles	All types of dynamite	Black blasting powder	Total
1938	71.8	12.6	84.4	15.6	100.0
1939	72.0	12.9	84.9	15.1	100.0
1940	72.1	13.8	85.9	14.1	100.0
1941	73.1	14.6	87.7	12.3	100.0
1942	72.1	16.8	88.9	11.1	100.0
1943	70.9	19.4	90.3	9.7	100.0
1944	68.7	22.1	90.8	9.2	100.0

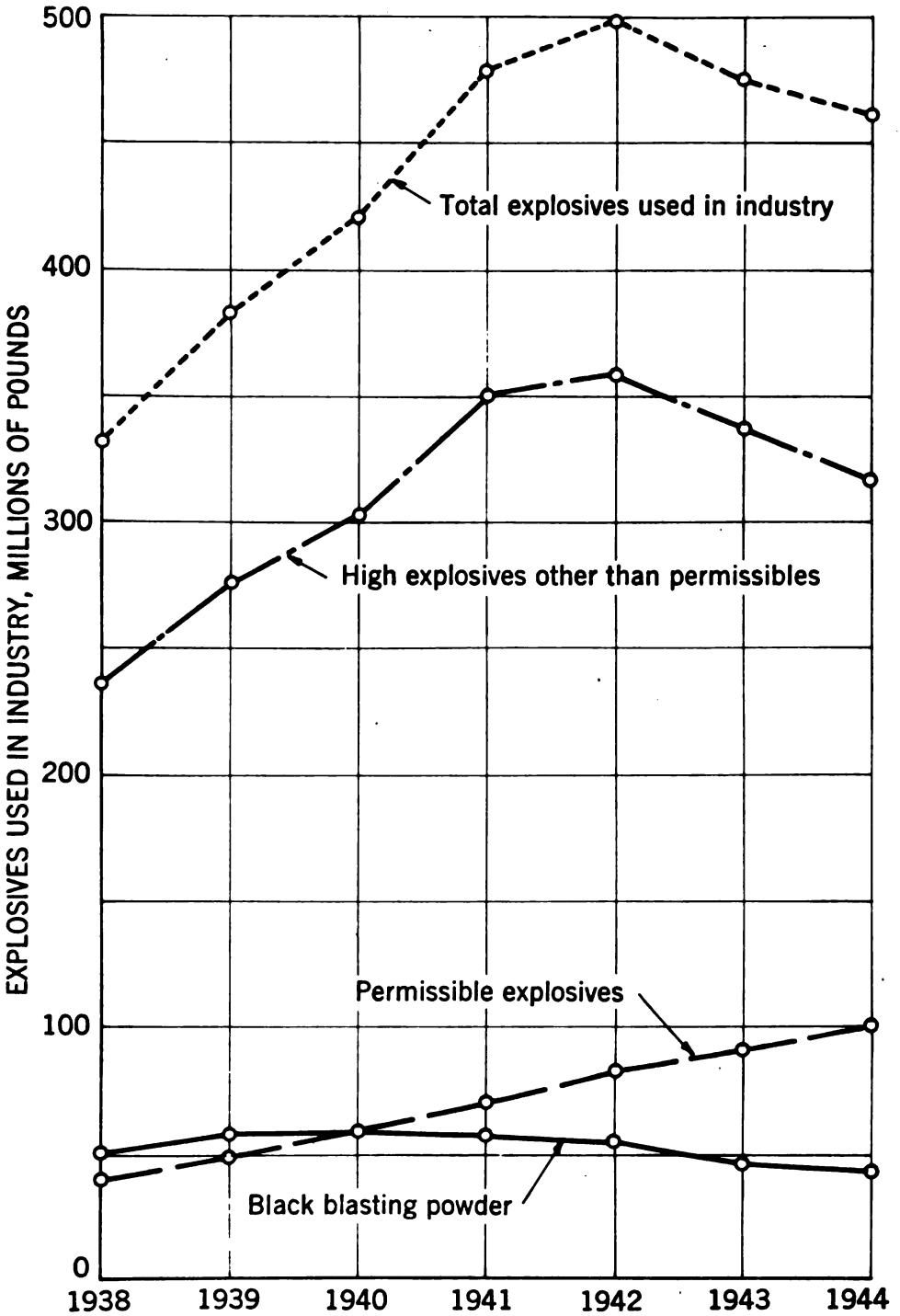
Mining and quarrying consumed 54.6 percent of the explosives used in industry in 1938 and 76.0 percent in 1944. Railways, construction, agriculture, and other types of work used relatively large amounts of explosives as shown in table 3.

TABLE 3. - Dynamite and permissible explosives used in industry, 1938-44, in pounds

Year	Mining and quarrying	Railway and other construction	All other purposes	Total
1938	181,397,459	85,743,195	13,294,869	280,435,523
1939	215,261,799	99,807,200	13,131,744	328,200,743
1940	250,616,485	102,134,470	10,864,875	363,615,830
1941	303,803,470	108,559,440	10,104,752	422,469,662
1942	331,134,521	104,580,307	8,010,390	443,725,218
1943	348,942,364	73,961,697	8,324,899	431,228,960
1944	352,530,818	59,272,595	9,348,135	421,151,548

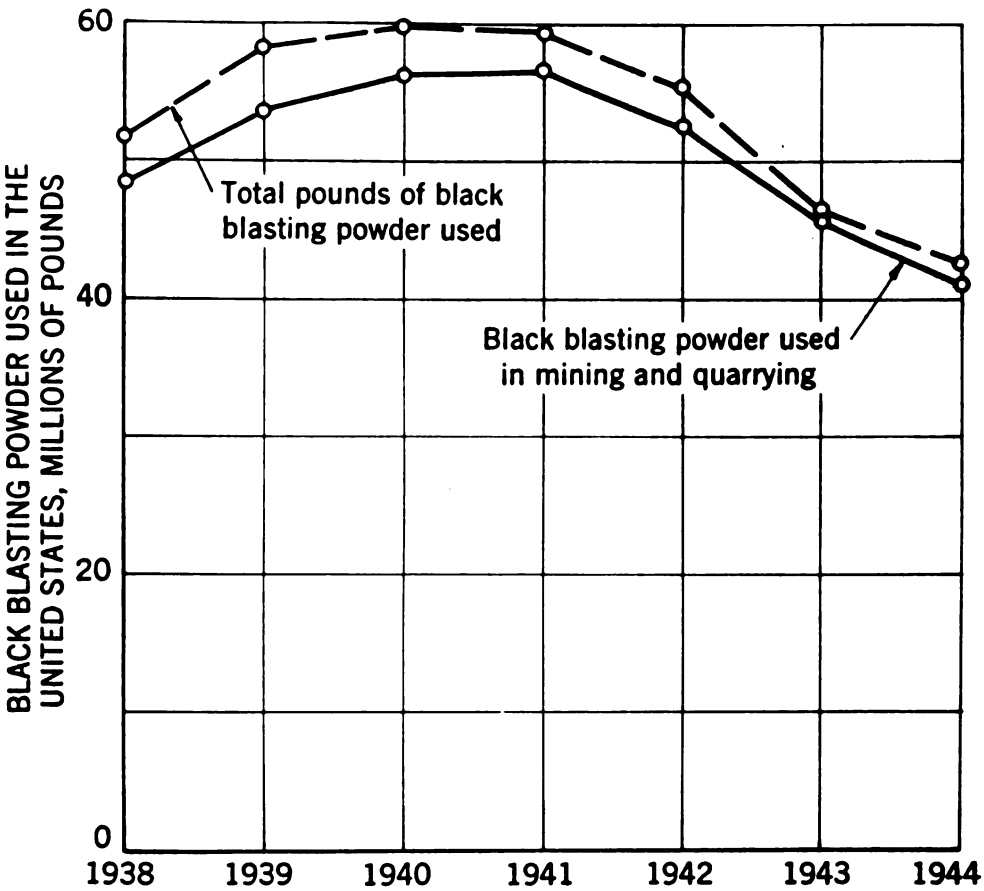
Black blasting powder used in the United States amounted to 42,959,775 pounds in 1944, as compared with 51,694,975 pounds in 1938 and 59,753,400 pounds in 1940. Coal mining consumed approximately 93 percent of the black blasting powder used in 1944. The annual use of black blasting powder in the period 1938-44, is shown in table 4 and graph B.

Generated on 2024-09-19 17:05 GMT / https://hdl.handle.net/2027/osu.32435030643852
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY



Graph A. - Explosives used in industry.

Generated on 2024-09-19 17:02 GMT / https://hdl.handle.net/2027/osu.32435030643852
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY



Graph B. - Black blasting powder used in the United States.

Generated on 2024-09-19 17:02 GMT / https://hdl.handle.net/2027/osu.32435030643852
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

TABLE 4. - Black blasting powder used in different industries, 1938-44, in pounds

Year	Mining and quarrying	Railways and other construction	All other purposes	Total
1938	48,290,975	3,037,000	367,000	51,694,975
1939	53,772,050	3,757,400	707,375	58,236,825
1940	56,337,850	2,547,875	867,675	59,753,400
1941	56,661,175	2,593,450	202,950	59,457,575
1942	53,044,000	2,392,200	97,550	55,533,750
1943	45,706,350	601,325	114,350	46,422,025
1944	41,619,500	1,117,125	223,150	42,959,775

DEFINITION OF EXPLOSIVES

An ordinary industrial explosive may be defined as any chemical compound or mixture that can be ignited or detonated by a blasting cap or an electric blasting cap that contains a charge of 2 grams of a mixture of 90-percent mercury fulminate and 10-percent potassium chlorate or its equivalent. A more general definition of an explosive is any substance, usually a chemical mixture, that has the property of yielding readily to combustion or oxidation upon the application of flame or shock, the combustion or oxidation process being rapid and accompanied by formation of such relatively large quantities of gases that much violence and pressure are produced; these in turn react against their surroundings and cause what is termed an explosion.

The intended action of all explosives is destructive and disruptive of adjacent materials; hence, all explosives are potentially hazardous, and every type of explosive, irrespective of its relative safety, should be handled, stored, and used with utmost care at all times and under all conditions. An explosive can be made safe only in certain of its features and under certain conditions and circumstances. Most types of modern explosives used in industry can be utilized advantageously with a considerable degree of safety if these facts are always kept in mind. The railroads of the United States transported more than 6,000,000,000 pounds of explosives in the last 20 years without injury to any person insofar as available records indicate, and this shows that explosives can be handled safely.

Commercial explosives may be considered to include high explosives, such as the dynamites and permissible explosives, the black blasting powders, some smokeless powders for ammunition used by sportsmen and for similar purposes, and the various kinds of igniters and detonators used to fire charges of high explosives and black blasting powder. Commercial explosives usually are very different from military explosives, and, in general, the two types are not suitable for interchange. However, considerable dynamite is used in military construction, a small amount of black blasting powder is used in loading shells, and some of the constituents of military explosives are used in the manufacture of commercial explosives.

Generated on 2024-09-19 17:01 GMT / https://hdl.handle.net/2027/osu.32435030643852
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

There are devices and systems that accomplish results essentially similar to well-defined explosives, such as dynamites and black blasting powder. These results are obtained by utilizing the expansive properties of liquid carbon dioxide, by the use of heavy pressure of air or other gas through a system of piping, and by utilizing the explosive effect of liquid oxygen. These devices and methods are destructive and disruptive of adjacent materials, and they are explosives in effect, if not in name or by exact definition, and should be handled with as much care as is the ordinary commercial explosive. The use of liquid carbon dioxide and high air pressure as explosives is confined almost entirely to coal mining, while the largest use of liquid oxygen for blasting in the United States is in strip coal-mining operations and, to a far lesser extent, traprock quarrying. Another relatively new explosive used to some extent in quarrying and often referred to as "safe" is an ammonium nitrate compound. However, all of these devices and compounds are intended to be destructive and are, in fact, explosives.

CHARACTERISTICS OF EXPLOSIVES

High explosives include the types that decompose by detonation. The detonation is an extremely rapid almost instantaneous, process, and the resultant action is violent and disruptive.

Commercial high explosives are usually termed dynamites. There are several classes and many grades of dynamites, each having its own properties and characteristics and designed for certain kinds of work. Broadly speaking, dynamites are classed as straight, gelatin and semigelatin, ammonia, and permissible.

Metal and nonmetallic mining consumes most of the commercial dynamite produced, while the permissible dynamites are used largely in coal mining. Many commercial explosives are composed of some proportion of nitroglycerin absorbed in other materials, such as wood pulp, sodium nitrate, or other absorbents. The absorbent is varied by introducing other materials of an explosive nature, or for the purpose of cooling or otherwise modifying some feature of the nitroglycerin in or after being fired.

Nitroglycerin is an oily substance about one and one-half times as heavy as water (sp.gr., 1.6), is almost insoluble in water, and is used as a principal or active ingredient in dynamite. It is used commercially in the form of a liquid for "shooting" oil wells. It is highly explosive and very sensitive to shock, friction, heat, and flame and an extremely hazardous substance to store, transport, or handle.

The choice of a suitable explosive to use for a given type of work is best-solved by consulting with a representative of some responsible explosives-manufacturing company; but the following properties should be considered when this advice is not available:

(1) Strength of dynamite refers to the energy content of an explosive, which in turn determines the force and power it develops and the work it is capable of doing.

Generated on 2024-09-19 17:07 GMT / https://hdl.handle.net/2027/osu.32435030643852
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

(2) The density of a dynamite is the weight per unit of volume. The chief purpose of density variations in explosives is to enable the blaster to concentrate or distribute the charges at will.

(3) The velocity of a dynamite is the measure, in feet per second, of the speed at which the detonation wave travels through a column of explosive; the velocity of detonation indicates the speed of action of an explosive. The explosive detonates more quickly as the velocity is increased, and it has a greater shattering effect.

(4) The water resistance refers to the ability of dynamites to resist the effects of water. Gelatin dynamite is practically waterproof.

(5) Modern commercial explosives will not freeze under the atmospheric conditions found in this country. Dynamite that is hard and believed to be frozen should not be thawed. The dynamite should be examined by a representative of the explosives-manufacturing company.

(6) The explosion of dynamite produces toxic and nontoxic gases or fumes that are principally carbon dioxide, nitrogen, and steam; under certain circumstances carbon monoxide, oxides of nitrogen, and hydrogen sulfide are present; carbon monoxide is nearly always found after blasting.

CLASSES OF DYNAMITES

Straight Dynamite

Straight dynamite is manufactured in varying strengths up to 60 percent. The percentage strength of a straight dynamite refers to the actual percentage of weight of nitroglycerin it contains. It is used chiefly for mud-capping, demolition, and blasting under water as it resists water well, particularly in the higher strengths. It has a high velocity, which gives a quick shattering action.

Straight dynamite should not be used underground or in confined places on account of the excessive amount of toxic fumes upon detonation.

Gelatin Dynamite

Gelatin dynamite is manufactured in grades ranging from 20 to 90 percent. The explosive base is a jelly made by dissolving nitrocotton in nitroglycerin. It is practically waterproof, very dense, and plastic. When well-confined, it has a high velocity and a quick shattering action. This explosive is used largely underground in wet work and where the ground is tight or extremely hard. The fumes of gelatin dynamite up to 60-percent grade are usually rated as satisfactory in connection with its use underground. The use of this explosive is limited, as it is more expensive than some other types.

Ammonia Dynamite

Ammonia dynamite is manufactured in strengths ranging from 15 to 60 percent and with many variations of grades. This type probably is employed more widely than any other kind of dynamite; it is used in quarrying, some underground mining, and agricultural work such as stump blasting.

Generated on 2024-09-19 17:17 GMT / https://hdl.handle.net/2027/osu.32435030643852
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

Ammonia dynamite has a lower velocity than straight dynamite, and fragmentation is not as great as when a straight dynamite is used; water resistance is lower than with either a straight dynamite or gelatin dynamite, although some grades may be used in wet work. The fumes from detonation of ammonia dynamite are less harmful than those from straight dynamites, and this permits their use in some kinds of underground work where the ventilation is good.

Many grades of ammonia dynamite are manufactured, and each has its own characteristics. They are designed for specific types of work and have a wide range in velocity, density, and other properties.

Permissible Dynamite

Permissible explosives are essentially dynamites modified by the introduction of material whose function, in general, is to decrease the flame temperature and, to a small extent, the length and duration of the flame when the explosive is detonated. The designation "permissible" is given to an explosive of a modified dynamite type after such explosive has passed certain tests by the Federal Bureau of Mines. The permissible character of such explosive depends not only upon the ingredients in the explosive but also on certain well-defined specifications as to handling and use. There are several different types, grades, and strengths of permissible explosives, such as ammonium nitrate permissibles, organic nitrate permissibles, and gelatin permissibles, but essentially all of those now used to any extent can be placed in either the ammonium nitrate or the gelatin class.

Ammonium nitrate permissible explosives contain relatively little nitroglycerin and relatively large proportions of ammonium nitrate, the latter being itself an explosive substance but one less sensitive to impact, sparks, and flames than nitroglycerin. This type of permissible explosive is used extensively, as it has a wide range of strength, rate of detonation, density, size of cartridge, etc., and can be utilized not only in dry holes but also, in some cases, in fairly wet holes if charged carefully and fired promptly after having been placed in the hole. Gelatin permissible explosives are more suitable than ammonium nitrate permissibles for wet holes, and in general they are stronger and more violent than are the ammonium nitrate types.

All permissible explosives are strong, must be used in relatively small quantities (less than 3 pounds) per hole to retain their permissibility, give off considerable quantities of toxic gases on detonation, and (while much safer than black blasting powder or dynamite) must be stored, handled, and used with care or they can be extremely hazardous.

Ammonium Nitrate Explosives

A comparatively new explosive marketed in sealed metal cans is used to a considerable extent in quarry blasting. The material in the cans is principally ammonium nitrate. This explosive is very insensitive and requires a special type of primer to detonate the charge. It cannot be detonated by blasting caps, detonating fuse, flame, or impact of a rifle bullet. So far, the use of this explosive in this country is limited generally to special conditions.

Generated on 2024-09-19 17:01 GMT / https://hdl.handle.net/2027/osu.32435030643852
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

Organic Nitrate Explosives

Organic nitrate explosives include the explosives containing organic nitrates other than nitroglycerin as their characteristic ingredient. Nitrostarch is the most common type in commercial use. It is not as water-resistant as nitroglycerin explosives and should not be used in wet work.

Liquid Carbon Dioxide

Liquid carbon dioxide is used as an explosive to some extent in coal mining. The liquid carbon dioxide is introduced into a cylinder or shell, the charge is fired with an igniter or heater which causes the liquid carbon dioxide to gasify, and the resultant pressure ruptures a metal disk which permits the pressure of the suddenly escaping gases to break down the coal.

Liquid-Oxygen Explosives

Liquid-oxygen explosive, commonly referred to as L.O.X. or Airmite, consists of a combustible, absorbent material saturated with liquid oxygen. The absorbent is made into a cartridge of the desired size and placed in a soaking vat containing liquid oxygen. The cartridges are placed in the blast hole and fired with a blasting cap or detonating fuse. The explosive effect is produced by the very rapid reaction between the oxygen and the combustible absorbent, initiated by the detonator; the reaction produces a large volume of gas at high temperature and pressure.

L.O.X. explosive is used principally in blasting overburden in strip-coal mines; it is not used underground in the United States but has been employed to a limited extent underground in European mines.

The extent to which explosives are used in metal mining is shown in table 5 for the period 1938-44. Explosives used in quarrying and nonmetallic mines in the same period are shown in table 6.

TABLE 5. - Explosives used in metal mining, 1938-44, in pounds

Year	High explosives other than permissibles	Permissibles	Black blasting powder	Total
1938	75,407,221	19,613	186,150	75,612,984
1939	88,061,417	17,450	201,250	88,280,117
1940	105,995,188	27,050	240,200	106,262,438
1941	116,343,629	19,125	58,525	116,421,279
1942	119,935,541	33,275	120,475	120,089,291
1943	122,653,309	26,345	62,950	122,742,604
1944	102,163,851	4,425	69,850	102,238,126

Generated on 2024-09-19 17:07 GMT / https://hdl.handle.net/2027/osu.32435030643852
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

TABLE 6. - Explosives used in quarrying and nonmetallic mining, 1938-44, in pounds

Year	High explosives other than permissibles	Permissibles	Black blasting powder	Total
1938	40,701,722	267,765	1,736,900	42,706,387
1939	53,732,399	387,250	2,402,300	56,521,949
1940	59,634,470	452,800	2,803,300	62,890,570
1941	78,403,268	550,925	3,100,150	82,054,343
1942	85,280,766	477,199	2,175,475	87,933,440
1943	79,646,758	420,799	2,048,325	82,115,862
1944	70,531,414	512,900	1,588,875	72,633,189

The extent to which explosives are used in industries other than mining is seldom realized. Table 7 shows the consumption of explosives in railway and other construction work in 1938-44, and table 8 shows the explosives used for all other purposes.

TABLE 7. - Explosives used in railway and other construction work, in pounds

Year	High explosives other than permissibles	Permissibles	Black blasting powder	Total
1938	85,692,095	51,100	3,037,000	88,780,195
1939	99,706,525	100,675	3,757,400	103,564,600
1940	102,059,140	75,330	2,547,875	104,682,345
1941	108,526,853	32,587	2,593,450	111,152,890
1942	104,463,977	116,330	2,392,200	106,972,507
1943	73,921,622	40,075	601,325	74,563,022
1944	59,095,495	177,100	1,117,125	60,389,720

TABLE 8. - Explosives used for all other purposes, 1938-44, in pounds

Year	High explosives other than permissibles	Permissibles	Black blasting powder	Total
1938	13,191,476	103,393	367,000	13,661,869
1939	13,087,390	44,354	707,375	13,839,119
1940	10,804,580	60,295	867,675	11,732,550
1941	10,068,313	38,439	202,950	10,309,702
1942	8,010,390	1/4,375	97,550	8,103,565
1943	8,291,877	33,022	114,350	8,439,249
1944	9,329,185	18,950	223,150	9,571,285

1/ Sold by manufacturer but later returned to him.

BLACK BLASTING POWDER

Black blasting powder is one of the oldest explosives used in commercial work and at one time was practically the only explosive readily obtainable. Most safety men are opposed to the use of black blasting powder, owing to the hazards involved in its use. It burns with extreme rapidity instead of detonating like high explosives; moreover, it is highly sensitive to flame, sparks, or friction and gives off much flame which is hot and of great length and duration. These properties make it extremely hazardous for use in mines

Generated on 2024-09-19 17:01 GMT / https://hdl.handle.net/2027/osu.32435030643852
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

and quarries, especially in coal mines. The gases given off in deflagration not only are very hot but frequently contain harmful constituents. Black blasting powder has action characteristics that make it valuable in both coal mining and quarrying, though it has little utility in metal mining. It is difficult to use it effectively in wet holes, which is the principal disadvantage from an efficiency standpoint.

Black blasting powder is manufactured in granular, pellet, or stick form. The pellet or stick powder is black blasting powder in consolidated form and has few advantages over granular black blasting powder, notwithstanding the prevalent idea that it is a "safe" explosive. Pellet powder was introduced in 1925.

TABLE 9. - Production of granular and pellet black blasting powder, 1942-44, in pounds

Year	Granular	Pellet	Total
1942	24,166,625	31,367,125	55,533,750
1943	19,814,125	26,607,900	46,422,025
1944	16,282,475	26,677,300	42,959,775

The use of black blasting powder in coal mines has gradually decreased over a period of many years. Bureau of Mines statistics show that 83 percent of all explosives used in mining coal in 1912 was black blasting powder, but in 1943 black blasting powder was only 23 percent of the total. The Bureau of Mines recommends the use of permissible explosives in coal mines in place of dynamite or black blasting powder, owing to the greater safety in handling and the decreased likelihood of causing a gas or dust explosion. The use of black blasting powder in mining coal in 1938-44 is shown in table 10.

TABLE 10. - Black blasting powder used in coal mines, in pounds

Year	Bituminous coal	Anthracite	Total
1938	41,533,100	4,834,825	46,367,925
1939	46,278,125	4,890,375	51,168,500
1940	48,425,425	4,868,925	53,294,350
1941	49,028,225	4,474,275	53,502,500
1942	46,352,075	4,395,975	50,748,050
1943	40,206,025	3,389,050	43,595,075
1944	36,772,875	3,187,900	39,960,775

Coal mines use large quantities of explosives other than permissibles and black blasting powder, particularly in these mines that must do considerable rock work. Table 11 shows the total amount of explosives of all kinds used in coal mines, excluding the blasting devices, such as liquid carbon dioxide. The increase in the use of permissible explosives in recent years is apparent. The large increase in the use of high explosives other than permissibles is attributed chiefly to the increase in the coal-stripping operations.

Generated on 2024-09-19 17:05 GMT / https://hdl.handle.net/2027/osu.32435030643852
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

TABLE 11. - Explosives used in coal mines, 1938-44, in pounds

Year	High explosives other than permissibles	Permissibles	Black blasting powder	Total
Bituminous coal:				
1938	10,877,970	28,492,998	41,533,100	80,904,068
1939	10,950,747	35,580,162	46,278,125	92,809,034
1940	12,554,235	43,920,765	48,425,425	104,900,425
1941	20,770,300	55,570,072	49,028,225	125,368,597
1942	22,629,688	67,514,542	46,352,075	136,496,305
1943	31,688,090	77,854,473	40,206,025	149,748,588
1944	50,299,995	87,180,247	36,772,875	174,253,117
Anthracite:				
1938	12,705,758	12,924,412	4,834,825	30,464,995
1939	12,711,850	13,820,524	4,890,375	31,422,749
1940	14,132,087	13,899,890	4,868,925	32,900,902
1941	17,745,090	14,401,061	4,474,275	36,620,426
1942	19,378,185	15,885,325	4,395,975	39,659,485
1943	22,371,785	14,280,825	3,389,050	40,041,660
1944	27,193,361	14,644,625	3,187,900	45,025,886

SMOKELESS POWDER

Smokeless powders have an entirely different composition from that of black blasting powder and are used chiefly for ammunition for operating guns and more widely for military purposes. They are sensitive to flame and impact but ordinarily are packaged so that, if reasonable judgment is used, they are relatively harmless. The burning speed of smokeless powder depends on the size of the powder grain; the larger the grain, the slower it burns.

DETONATORS AND IGNITERS

The safe and efficient use of any explosive requires the use of a safe and efficient means of detonation, otherwise the person or persons doing the blasting may be killed or injured; also, an explosive, unless efficiently detonated, does not develop the full disruptive effect. Several devices or methods are used and are intended to develop safely the full power of the explosive. They fall in three general classes - detonators, igniters, and detonating fuse.

Detonators are of two kinds - blasting caps and electric blasting caps. Blasting caps must be fired with a fuse and cannot be used effectively when a number of charges must be fired simultaneously. Electric blasting caps are of two general types - instantaneous and delay. The instantaneous type is used when it is desired to explode all of the explosive charges simultaneously, and the delay electric blasting caps are used when it is desired to fire the charges of explosives in some sequence.

Generated on 2024-09-19 17:02 GMT / https://hdl.handle.net/2027/osu.32435030643852
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

Blasting Caps

Blasting caps are small, metallic cylinders, usually of copper, about 3/16 inch in diameter and 1-1/2 to 2 inches long, closed at one end and containing one or more charges of explosives, one of which is easily ignited from the flame of a safety fuse. Tetryl or fulminate of mercury is used as the explosive in most blasting caps. They are extremely sensitive to heat, friction, shock, or any kind of a blow and should be handled very carefully. Dirt or foreign material may lodge in the open end of a cap; this makes it extremely dangerous when inserting the safety fuse especially if the blasting cap is rotated on the fuse. The common strength of blasting caps used in industry is No. 6, but No. 8 strength is also used to a lesser extent. Blasting caps should not be carried loose and should not be stored or carried with explosives. They can be handled with relative safety if care is used; partial proof of this is that blasting caps are manufactured and shipped by the hundreds of thousands every day, and accidents are decidedly rare.

Electric Blasting Caps

Electric blasting caps are similar to ordinary blasting caps but are fired with electricity; this is done by inserting two wires within the cap joined with a bridge of high-resistance material that heats when the electric current is applied, thus igniting the explosive charge inside the cap.

Standard electric blasting caps are water-resistant and may be used satisfactorily under wet conditions that are not very severe. Care should be taken not to bend the wires sharply or pull them apart where they enter the seal at the end of the cap, otherwise the seal may be broken and the cap made less water resistant.

The leg wires of the electric blasting caps are either copper or iron wires, depending on the use, and almost any reasonable length of leg wire can be obtained. The ends of the leg wires should be twisted together to protect against stray currents. Many electric blasting caps are provided with shunts which effectually short-circuit the cap until it is ready to be connected for firing.

Instantaneous electric blasting caps provide an efficient means of firing essentially any number of charges of explosives at one time.

Delay electric blasting caps are similar to the instantaneous type, except that a delay element is placed between the firing element and the detonating charges, making it possible to fire the charges of explosives in sequence. Delay electric blasting caps are provided with time intervals up to 10; the time interval ranges from about 1 second in the first delay to about 2-1/2 seconds between the ninth and tenth delays. The time interval for each delay cap is not exact but is nearly so.

Instantaneous and delay electric blasting caps should not be connected in the same circuit. When it is necessary to use both types of blasting caps in one blast, the instantaneous blasting caps should be placed in one series, and the delay caps in another series; all circuits should be connected in parallel.

Generated on 2024-09-19 17:15 GMT / https://hdl.handle.net/2027/osu.32435030643852
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

Detonating Fuse

Primacord is the principal detonating fuse in use in the United States and has practically replaced Cordeau. It consists of a flexible fuse with a high-explosive core of pentaerythritetetranitrate (PETN), which is contained within a waterproof sheath overlaid with reinforcing coverings. The detonating velocity is over 20,000 feet a second, which causes almost instantaneous detonation of long columns of explosives. Primacord is used in detonating well drill holes and coyote holes and in diamond-drill-hole blasting, but is not generally used in short holes.

Primacord is very insensitive and cannot be detonated by fire, friction, or shock of a rifle bullet. Usually it is considered to be the safest detonant in use for well-drill-hole blasting or other work where long columns of explosives are used. Primacord is detonated with a blasting cap or electric blasting cap that is attached to the detonating fuse with a connector provided for the purpose, or by taping a detonating cap alongside and at the end of the detonating fuse. The end of the cap containing the charge of explosives should always be pointed in the direction in which the detonation is to proceed.

Igniters

Igniters include squibs, electric squibs, delay electric squibs, and delay electric igniters. Igniters are used to fire black blasting powder and are not used to detonate high explosives.

Squibs

The squib is a small-diameter tube of straw or paper filled with a quick-burning powder and having a relatively slow burning "match head" attached to one end. The latter is ignited by a flame, and its relatively slow burning allows the person handling the ignition to retire before the fire reaches the quick-burning powder in the tubes. Squibs are not considered to be safe or efficient to use.

Electric Squibs

Electric squibs are ignited by an electric current in place of a flame. They resemble electric blasting caps in general design, but the shell is made of paper, aluminum, or copper. It is designed to ignite the black blasting powder at the center of the charge, which is impossible with a regular squib. Electric squibs are considered by some authorities to be the safest and most effective means of firing black blasting powder.

Delay Electric Squibs

Delay electric squibs are similar to regular electric squibs, except that delay elements are inserted between the firing element and the deflagrating charge. Delay elements provide 10 periods of delay, and their use makes it possible to fire the charges of black blasting powder in sequence.

Generated on 2024-09-19 17:01 GMT / https://hdl.handle.net/2027/osu.32435030643852
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

Delay Electric Igniters

Delay electric igniters are made up of a copper tube with an electrical firing element and leg wires sealed into one end, and a piece of fuse crimped into the other end. The length of the fuse determines the delay interval of the igniter. The free end of the fuse is dipped in a waterproofing compound, and about 1 inch is cut from the end before using the igniter. These igniters are not recommended by the Bureau of Mines for use underground in coal mines.

SAFETY FUSE

Safety fuse, often referred to as just "fuse," consists of a train of black blasting powder tightly wrapped and enclosed in various wrappings of textiles and waterproofing materials that protect the powder train from abrasion and resist the penetration of water. The wrappings are designed to prevent intercommunication of fire between adjacent lengths and to minimize the danger of setting fire to the charge of explosives by sparks coming through the side of the fuse before the fire reaches the end.

Safety fuse is manufactured by several companies and is obtainable in two standard rates of burning. The manufacturers of safety fuse make no guarantee or representations as to the burning speed of their product, owing to the many circumstances and conditions to which the fuse is subjected after leaving the factory, including differences in altitude, weather conditions, character of tamping, and mishandling, all of which may affect the burning speed of the fuse. However, every care and precaution is used in the manufacture of safety fuse to have it burn at a standard speed of either 30 seconds or 40 seconds per foot, with an allowable variation of 10 percent either way from standard when burned in the open at sea level.

One of the most prolific causes of accidents resulting from safety fuse is using fuse that is so short that the blaster does not have time enough to reach a safe place before the explosives are detonated. The burning rate of fuse should be tested frequently, and each blaster should be required to know the speed at which the fuse burns. Fuse less than 30 inches long should not be used; this length will allow 1 minute and 40 seconds before the explosives detonate if the burning rate is 40 seconds per foot, and 1 minute 15 seconds if it burns at the rate of 30 seconds per foot. It should be remembered that the burning rate of fuse may vary 10 percent, and allowance should be made for this.

The use of poorer grades of fuse, because of the lower cost, is decidedly poor economy. If the fuse is to be used in wet work, it should be selected for its waterproof qualities with a view to avoiding misfires.

BLASTING MACHINES

Blasting machines are used to fire electric blasting caps and electric squibs when electric power is not available. The blasting machines are often used because they provide a quick, simple method of blasting electrically.

Generated on 2024-09-19 17:04 GMT / https://hdl.handle.net/2027/osu.32435030643852
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

Some blasting machines are magnetos, but the majority are modified generators; they are ruggedly built and will withstand hard service if given reasonable care. Blasting machines are rated according to the number of electric blasting caps with 30-foot lead wires that can be fired when the caps are connected in straight series.

The magneto type is used to fire one shot and is employed principally in coal mining. The larger types are modified generators and will fire up to 100 electric blasting caps at one time when connected in series.

All blasting machines should be operated quickly to develop the maximum capacity of the machine; that is, the handle of the twist type should be given a quick turn, or, if the machine is the rackbar type, the handle should be thrust down quickly. Blasting machines should be tested frequently to insure that the capacity has not been impaired. This is done by connecting a blasting rheostat in series with one cap of the type in use.

STORAGE OF EXPLOSIVES

Explosives are inherently hazardous and definitely perishable so that certain precautions must be taken to achieve reasonable safety. The two important factors to be considered in the storage of explosives are (1) protection of the explosives within the magazine and (2) protection of life and adjoining property.

Magazines should be protected against heat, extreme changes in temperature, moisture, fire, lightning, bullets and projectiles, and theft. The magazines should be weatherproof, fire-resistant, bullet-resistant, well-ventilated, and securely locked.

Magazines should be erected far enough from other buildings, or vital structures of any sort, so that the least possible damage may be done to persons or buildings in the surrounding area should there be an explosion. Advantage should be taken of the available means of protecting a magazine, such as hills, spoil banks, rock ledges, dense woods, or any other natural means of protection. Sandy soil is preferable as a site to rocky ground. Shallow tunnels or dug-outs in the side of a hill make excellent storage magazines if the magazine can be well-drained and well-ventilated.

The distance of the site of an explosives magazine from an inhabited building, public railways, and public roads is shown in the American Table of Distances, 1919 revision, which can be obtained from the Institute of Makers of Explosives or from the Federal Bureau of Mines.

Construction of Magazines

Much has been written relative to the construction of explosives magazines. The Institute of Makers of Explosives has issued a publication, Standard Storage Magazines, and the Bureau of Mines Information Circular 7307, Surface Storage of Explosives; both have detailed descriptions of recommended construction of magazines. Only general details of construction of magazines are discussed in this publication. Figures 1, 2, 3, and 4 illustrate some recommended types of construction. Three general types are preferred, (1) brick, (2) sand-filled, and (3) portable steel magazines, lined with brick or other material.

Generated on 2024-09-19 17:03 GMT / https://hdl.handle.net/2027/osu.32435030643852
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

Generated on 2024-09-19 17:02 GMT / https://hdl.handle.net/2027/osu.32435030643852
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google

Digitized by Google

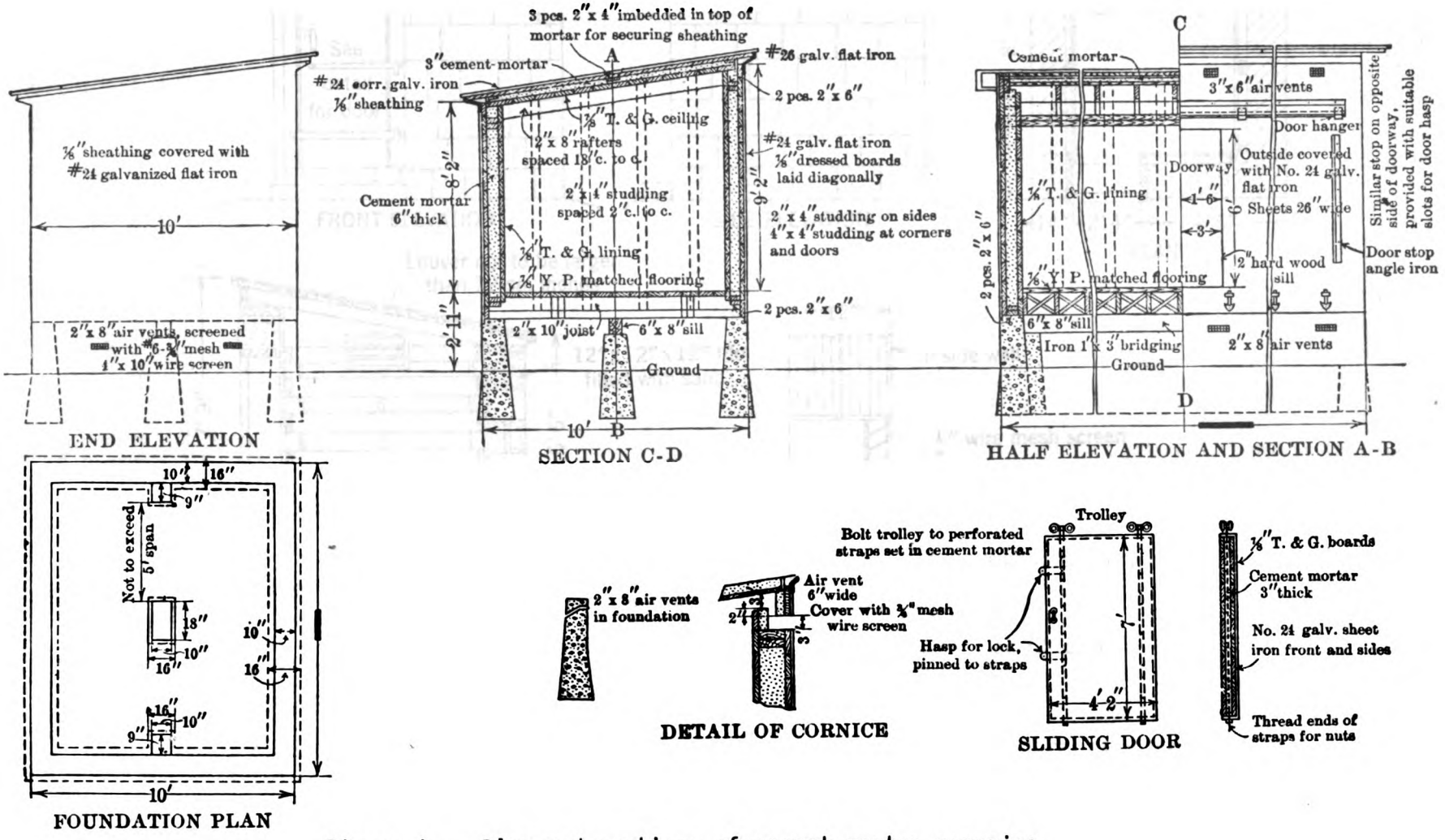


Figure 1. - Plan and sections of cement-mortar magazine.

Original from THE OHIO STATE UNIVERSITY

Generated on 2024-09-19 17:06 GMT / https://hdl.handle.net/2027/osu.32435030643852
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google

Digitized by Google

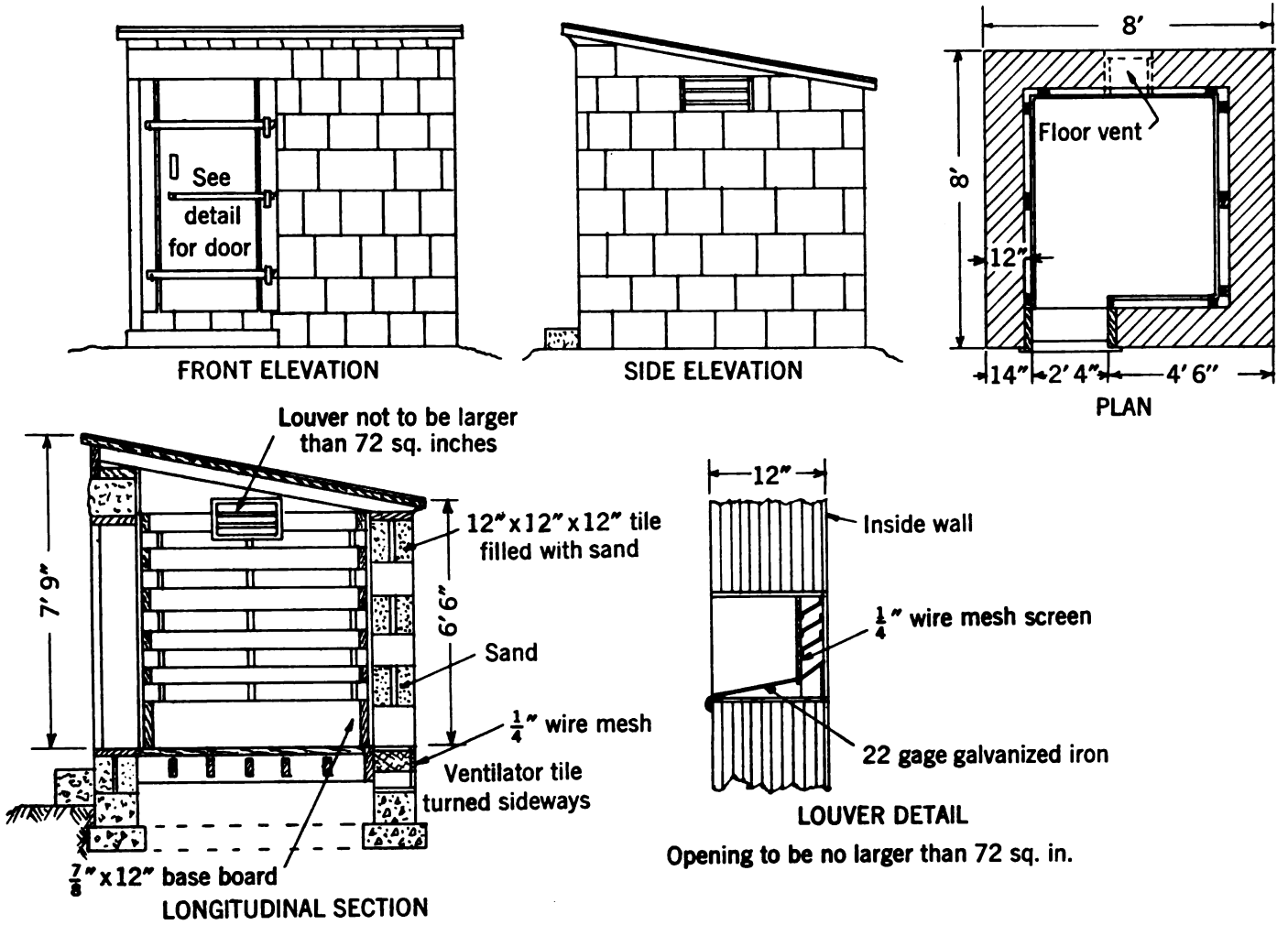


Figure 2. - Magazine of simple construction for storing small quantities of explosives (capacity about 4,000 to 4,500 pounds). Construction: 12- by 12- by 12-inch hollow tile with cells filled with screened sand, but may be constructed of other material such as soft brick, weak concrete or masonry, cement, or concrete blocks with cells filled with screened sand, cement mortar, or other bullet-resistant filler; walls to be not less than 6 inches thick; and louvers or ventilators to be not larger than 72 square inches. Size and type of vents will depend on kind of material used. Foundation will vary with thickness of wall (sketch is for 12-inch walls).

Original from THE OHIO STATE UNIVERSITY

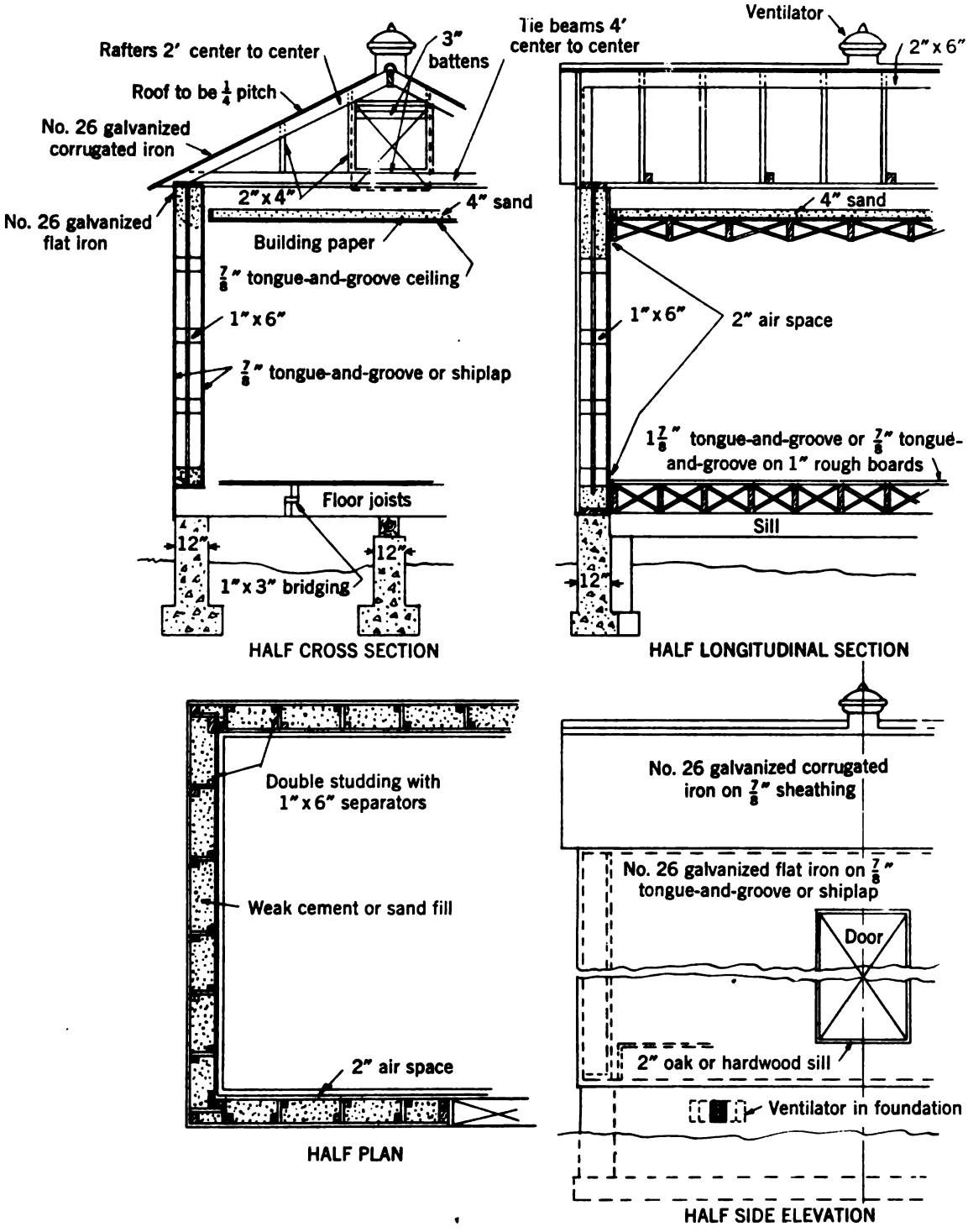


Figure 3. - Standard sand-filled or weak concrete-filled magazine (recommended by The Institute of Makers of Explosives). Specifications: Outside and inside sheathing to be tongue-and-groove boards to prevent loss of sand; space between outside and inside sheathing to be filled with weak concrete mortar, approximately 1 part Portland cement and 7 to 10 parts sand or 6 to 12 inches of weak mortar over the sills and coarse, dry sand in the remaining space; bullet-proof sand roof as shown; floor and ceiling to stop 2 inches from walls to provide ventilation; and nails in walls and floors to be concealed.

Generated on 2024-09-19 17:12 GMT / https://hdl.handle.net/2027/osu.32435030643852
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

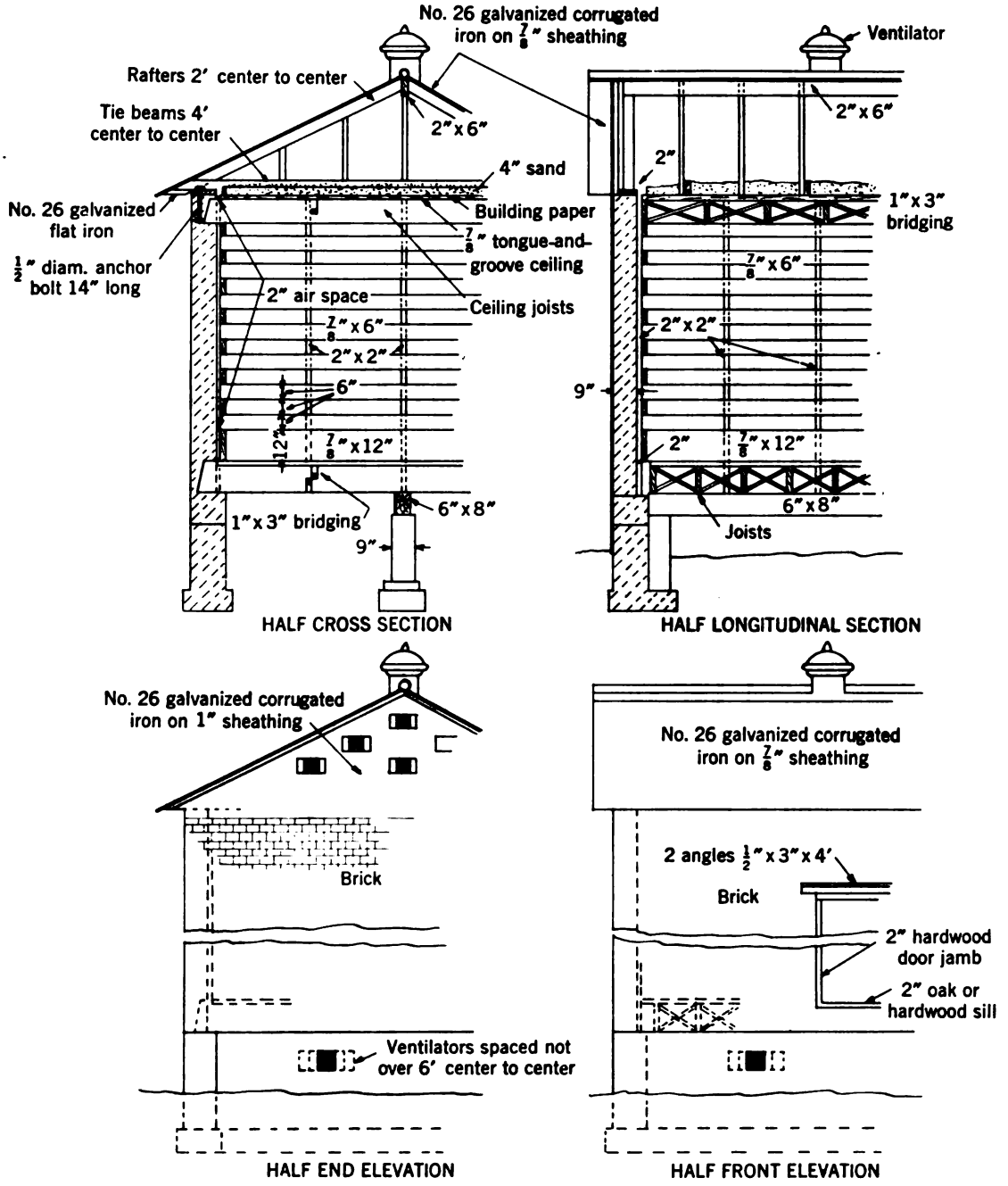


Figure 4. - Standard brick magazine (recommended by The Institute of Makers of Explosives). Specifications: Brick to be medium-soft and laid in cement mortar containing not over 25-percent lime; no metal to come in contact with explosives packages; floors to be blind-nailed and lining nails to be countersunk; floors and ceiling to stop at 2- by 2-inch lining supports, leaving 2-inch ventilation spaces around the walls; lattice lining, as shown, with 12-inch base boards and 6-inch wall boards spaced 6 inches apart; gable or hip roof; bullet-proof sand roof as shown; box formed by laying floor of tongue-and-groove boards on ceiling joists and building 1- by 4-inch rim line with one layer of building paper and filling with not less than 4 inches of coarse, dry sand. If bullet-proof roof is not necessary, a ceiling should be built of 7/8-inch tongue-and-groove boards or wall boards to stabilize temperature within the magazine.

Generated on 2024-09-19 17:03 GMT / https://hdl.handle.net/2027/osu.32435030643852
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

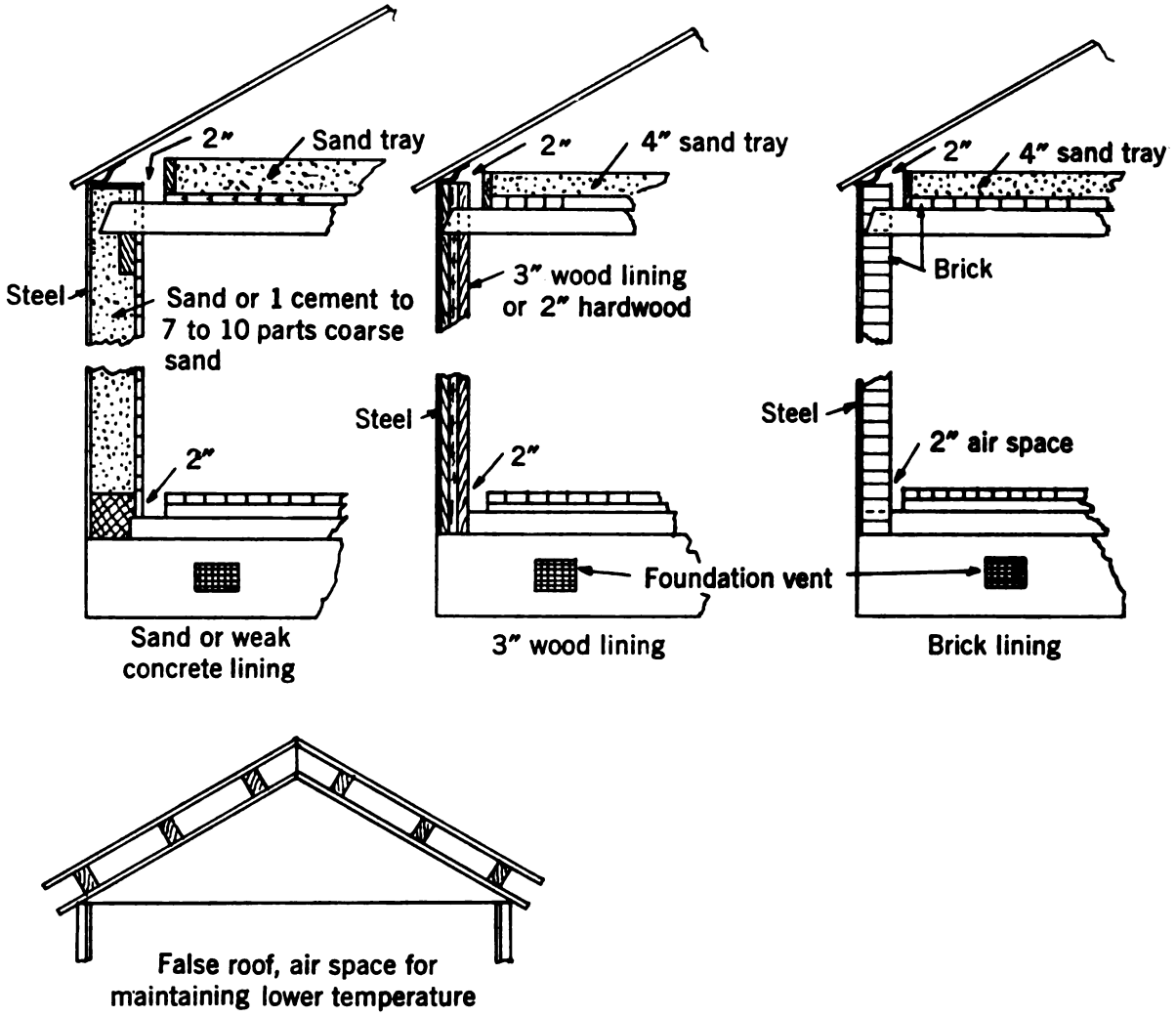


Figure 5. - Linings for steel magazines. Specifications: Metal should not come in contact with stored explosives; floors to be blind-nailed and lining nails to be countersunk; and false roof or 7/8-inch ceiling to be used when necessary to maintain temperature in magazine.

Generated on 2024-09-19 17:02 GMT / https://hdl.handle.net/2027/osu.32435030643852
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

Generated on 2024-09-19 17:01 GMT / https://hdl.handle.net/2027/osu.32435030643852
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google

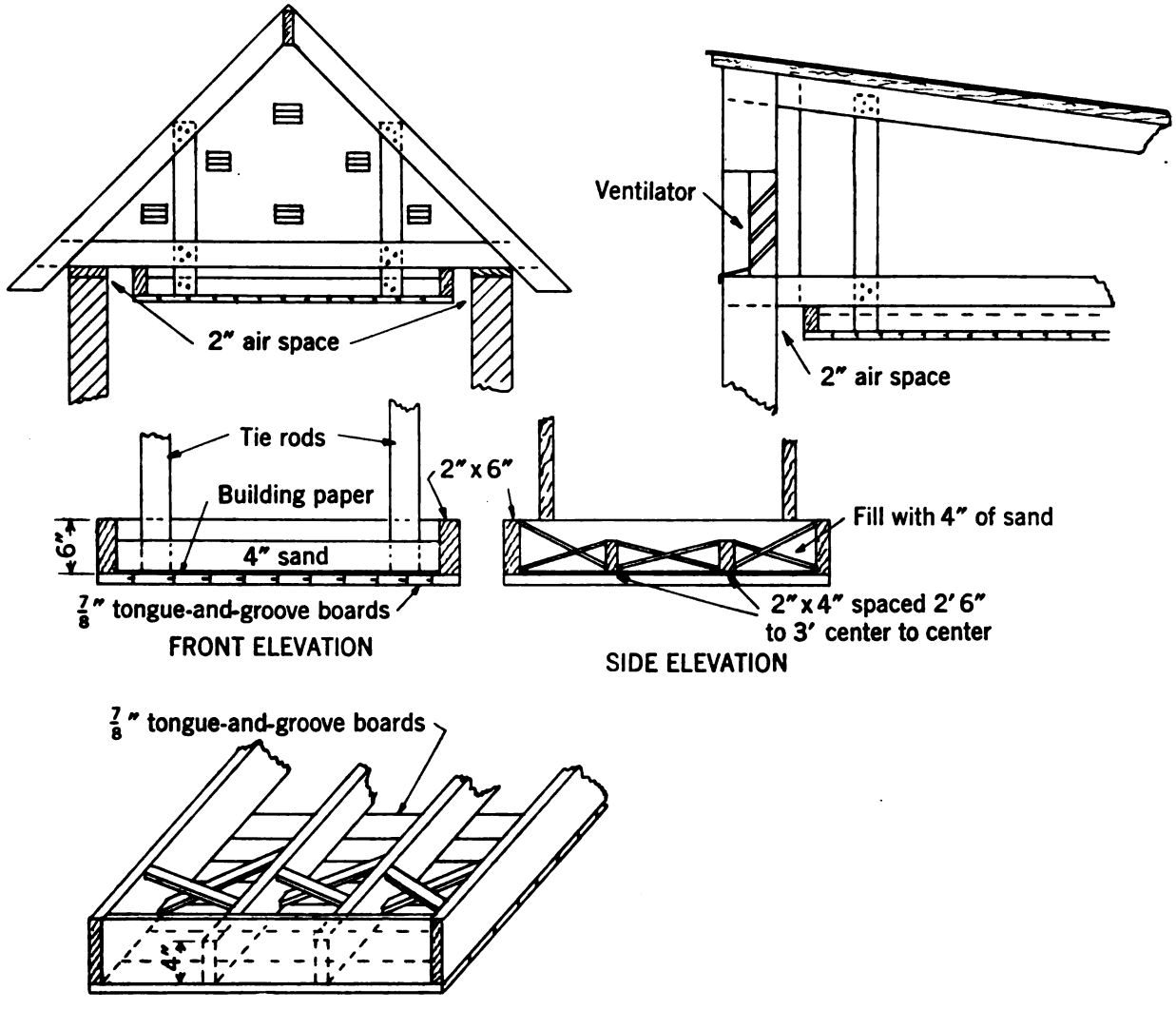


Figure 6. - Method of constructing a sand-tray ceiling. Construction: Side and end of box to be built of 2- by 4-inch boards and installed as needed, depending on size of box; bottom of box to be 7/8-inch tongue-and-groove boards covered with building paper; box to be filled to the top of the 2 by 4's with dry, coarse sand; brace roof as needed to carry weight of sand tray; and tie rods may be of steel or wood, the number used depending on size of box.

Digitized by Google
Original from THE OHIO STATE UNIVERSITY

Generated on 2024-09-19 17:12 GMT / https://hdl.handle.net/2027/osu.32435030643852
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google

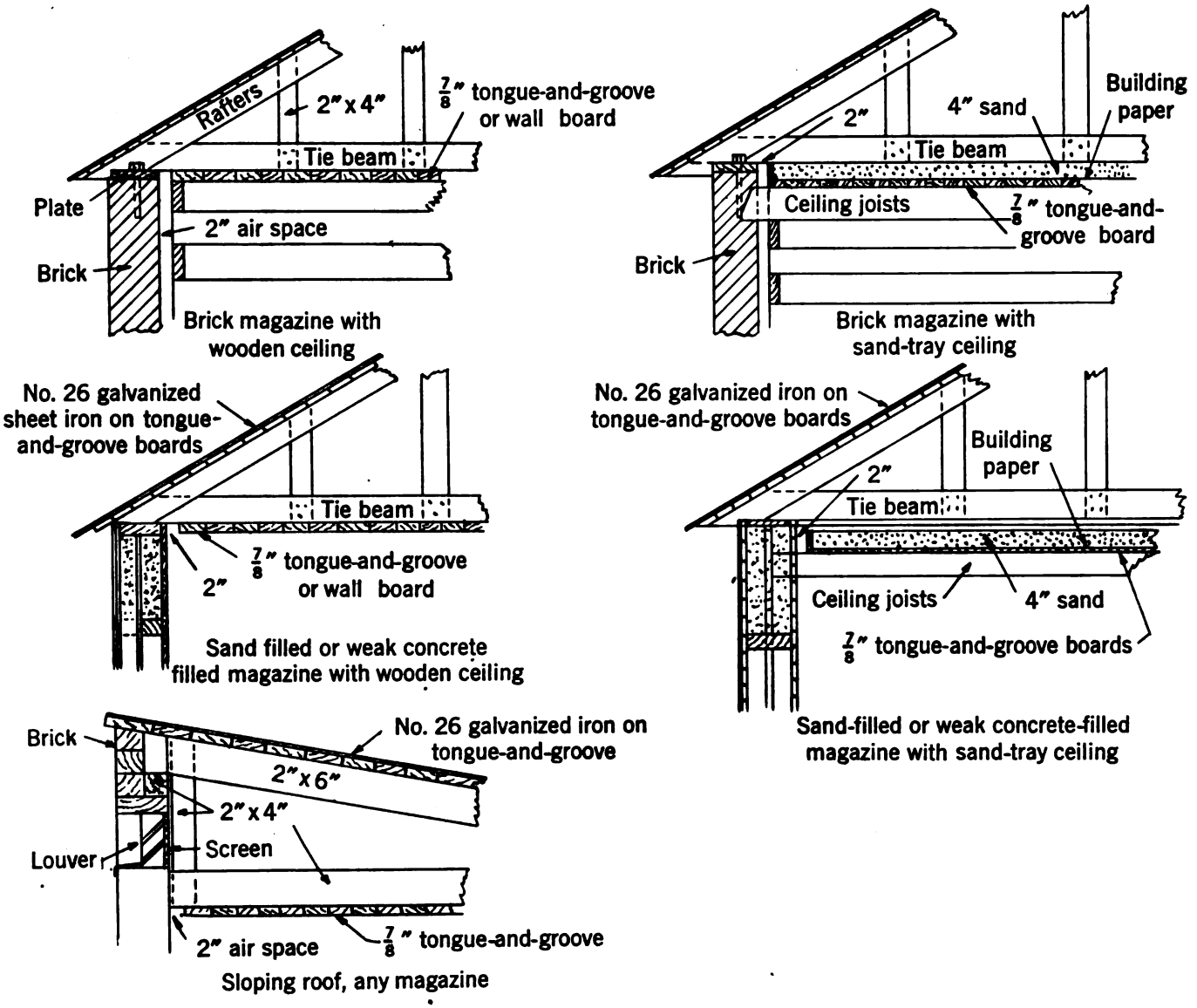


Figure 7. - Method of installing sand trays and ceilings in magazines of various types.

Digitized by Google
Original from THE OHIO STATE UNIVERSITY

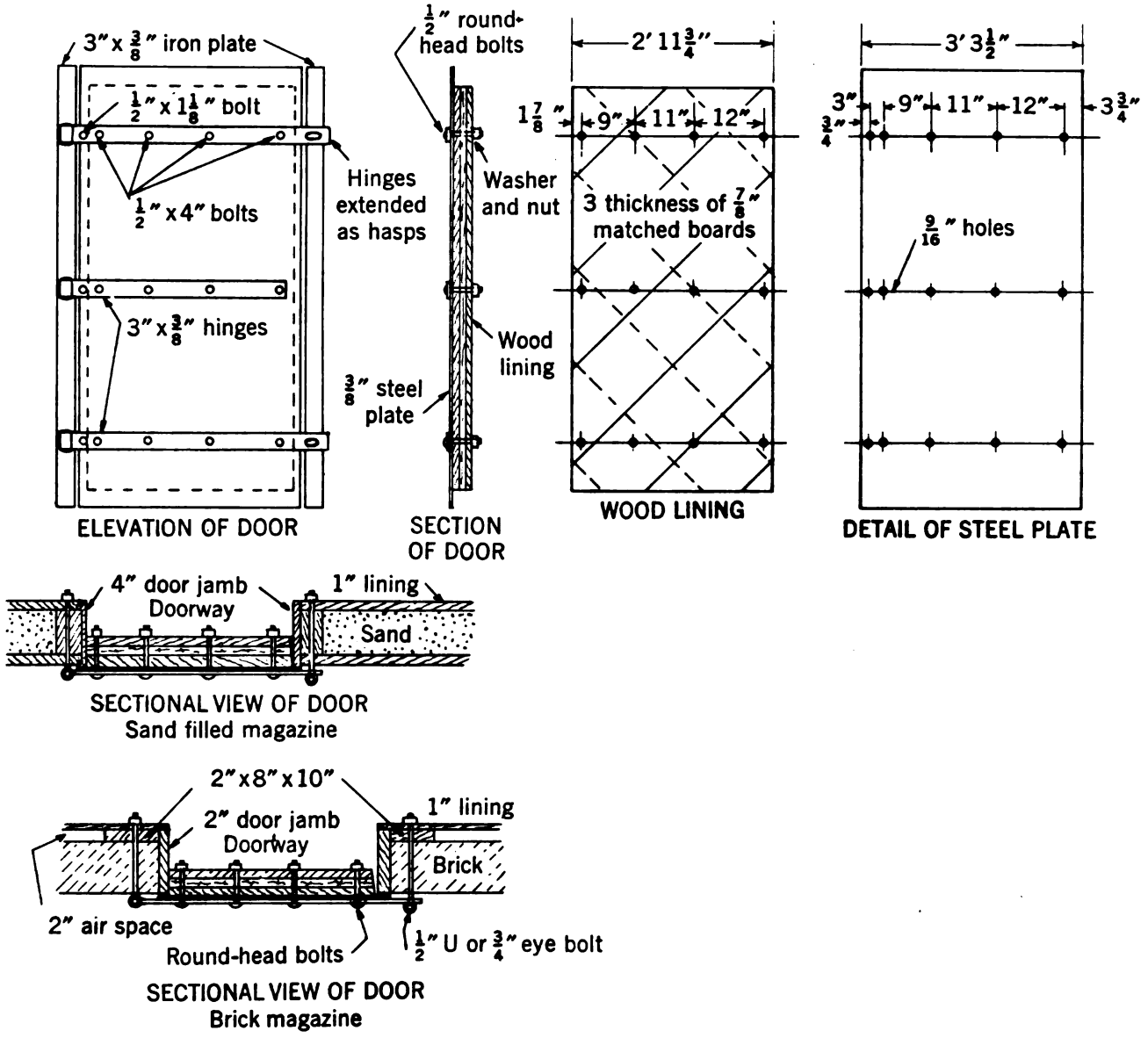


Figure 8. - Sketch of an easily constructed magazine door (can be used for a door of any dimensions). Construction: Three thicknesses of 7/8-inch tongue-and-groove boards are laid diagonally back of a 3/8-inch steel plate; doors should be 3/8-inch steel plate and lined with at least a 2-inch thickness of wood, a thinner plate may be used when an additional inch of wood is used for each 1/8-inch decrease in thickness of steel plate; hinges and staples to be attached by welds, rivets, or bolts fitted with lock washers and nuts on the inside; door to be equipped with two padlocks fastened in separate staples; and top and bottom hinge straps to be extended to cover iron plate for hasp and either U or I bolt for staple, or two hasps and staples substituted.

Generated on 2024-09-19 17:04 GMT / https://hdl.handle.net/2027/osu.32435030643852
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

Generated on 2024-09-19 17:05 GMT / https://hdl.handle.net/2027/osu.32435030643852
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google

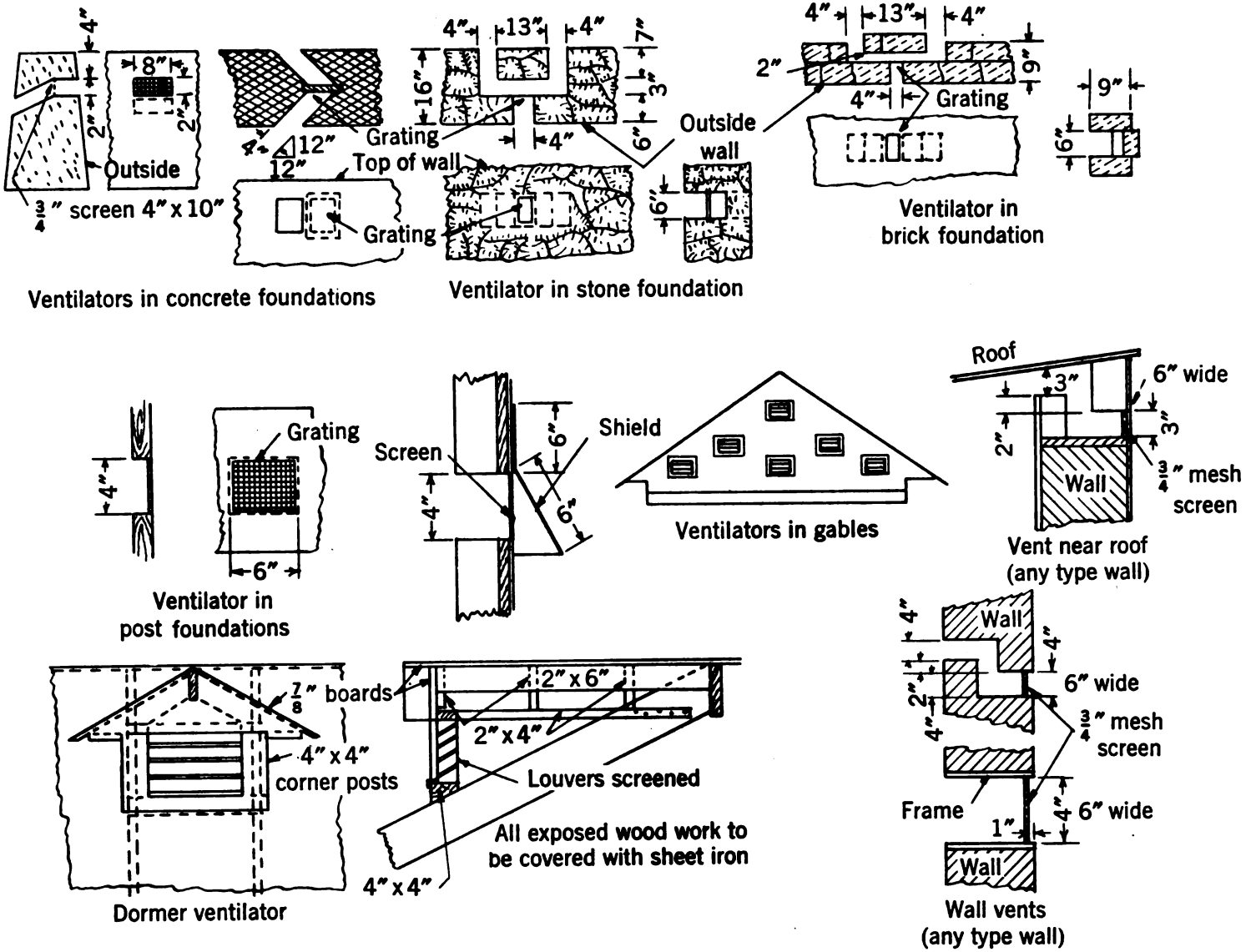


Figure 9. - Magazine ventilation.

Digitized by Google
Original from THE OHIO STATE UNIVERSITY

Brick magazines should be built of medium-soft brick laid in cement mortar containing not over 25 percent lime. The walls should not be less than 8 inches thick.

Sand-filled magazines should have walls not less than 6 inches thick. The walls should be tight and the space between the interior and exterior sheathing filled with dry sand - crushed stone or gravel should not be used. A mixture of 1 part cement and 8 parts sand, with enough water to moisten the mixture while tamping in place, is recommended. The exterior of the building should be covered with sheet iron of not less than No. 26 gage, or other fire-resistant material.

Portable steel magazines with sides and walls of not less than 14-gage metal are used. This type of magazine should be lined with 4 inches of medium-soft brick, 6 inches of sand filling, a mixture of 1 part of cement and 8 parts of sand, with enough water to dampen the mixture while tamping into place, or 3 inches of wood. Figure 5 illustrates a method of lining a steel magazine.

The roofs of magazines so situated that it is possible to fire bullets directly through the roof into the magazine should be made bullet-resistant by material of construction, by a ceiling that forms a tray containing not less than a 4-inch thickness of sand or other equally effective bullet-resistant filler erected in the interior of the magazine, or by other effective bullet-resistant methods. Figures 6 and 7 show methods of installing sand trays and ceilings in magazines.

The doors of magazines should be constructed of 3/8-inch steel plate lined with a 2-inch thickness of wood (a thinner steel plate may be used with a greater thickness of wood at the rate of 1 additional inch of wood for each 1/8-inch decrease in the thickness of the steel); or wooden walls at least 4 inches apart filled with screened sand or other effective bullet-resistant filler, the exterior being covered with sheet iron not lighter than No. 26 gage or other fire-resistant material. Figure 8 shows methods of constructing doors for magazines.

Magazines should be well-ventilated, both in the roof and in the foundations, to protect the explosives from heat and extreme changes of temperature that may cause the explosives to deteriorate. The openings for ventilation in the foundation should be enclosed in such a manner as to prevent the entrance of persons, animals, rubbish, sparks, and firebrands or the direct penetration of bullets that can detonate the explosives. The space between the floor of the magazine and the ground should be tightly closed, except for the ventilation openings. Vents in the foundation should be so spaced as not to exceed 6 feet, center to center, and should not be more than 6 inches wide and 12 inches long. The size and number of ventilators will vary with the climate, size of the magazine, and type of explosives in storage. Figure 9 shows methods of providing ventilation in magazines.

Magazines used exclusively for the storage of black blasting powder need not be bullet-resistant.

Generated on 2024-09-19 17:11 GMT / https://hdl.handle.net/2027/osu.32435030643852
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

Box-type magazines are used as an operations storage box for storing 1 day's supply of explosives a safe distance from an operating unit. The box-type magazine should be constructed of 2-inch hardwood or 3-inch softwood, or other theft-resistant material. Any metal magazine should be lined with a nonsparking material. Doors or lids should be provided with strong hinges, hasps, and staples attached by welds, rivets, or bolts fitted with lock washers and nuts on the interior of the magazine and installed in such manner that the fastenings cannot be removed when the magazine is locked. Figure 10 illustrates a recommended construction of a box-type magazine. Box-type magazines should be anchored securely to prevent the unauthorized removal of the magazine.

Doors of all magazines, including the lids of operation boxes, should be equipped with the equivalent of 5-tumbler jarproof locks; when it is practical to do so, it is recommended that a shroud be placed over the lock and hasp as a preventive measure against the use of some tool to forcibly remove or break the lock. The use of two locks on all permanent storage magazines is recommended; these locks can be of the mortise type, or one lock of a mortise type can be used that requires two keys to open or a 3-point lock.

Magazines should not be used to store material other than explosives; blasting caps, electric blasting caps, or any type of igniter should be stored in a separate magazine and not with high explosives or black blasting powder. Fuse and detonating fuse can be stored safely in an explosives magazine.

Open flame of any kind should not be permitted in or around a magazine, and if artificial light is needed, only an electric flashlight or electric lantern should be used. Oil-burning and chemical lamps or lanterns, candles, and matches should be prohibited.

The premises on which a permanent magazine is situated should be marked conspicuously by signs containing the words "EXPLOSIVES-KEEP OFF." These signs should be placed so as not to direct general public attention to the location of the magazine, but to adequately warn any person approaching the magazine of the presence of explosives. The signs should not be placed on the sides of magazines and barricades or so located that a bullet passing directly through the face of the sign will strike the magazine.

Barricades around magazines greatly reduce the extent of the danger to persons and property in the surrounding area as the force of an explosion is directed upward by the barricade. All permanent magazines should be barricaded.

TRANSPORTATION OF EXPLOSIVES

The manufacturers and railroads have set an excellent example in safety in the transportation of explosives, since there have been practically no accidents from this cause for many years although several billion pounds of explosives were transported on railroads. The problem of transporting explosives safely from a railroad car to the magazine of the user or vender of explosives is serious and deserves more attention than is generally given.

The Interstate Commerce Commission has issued numerous explicit regulations on the transportation of explosives on railways and by trucks, and the users of explosives would profit by familiarizing themselves with these regulations and by being governed by them. Railroad companies formulate and issue

Generated on 2024-09-19 17:04 GMT / https://hdl.handle.net/2027/osu.32435030643852
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

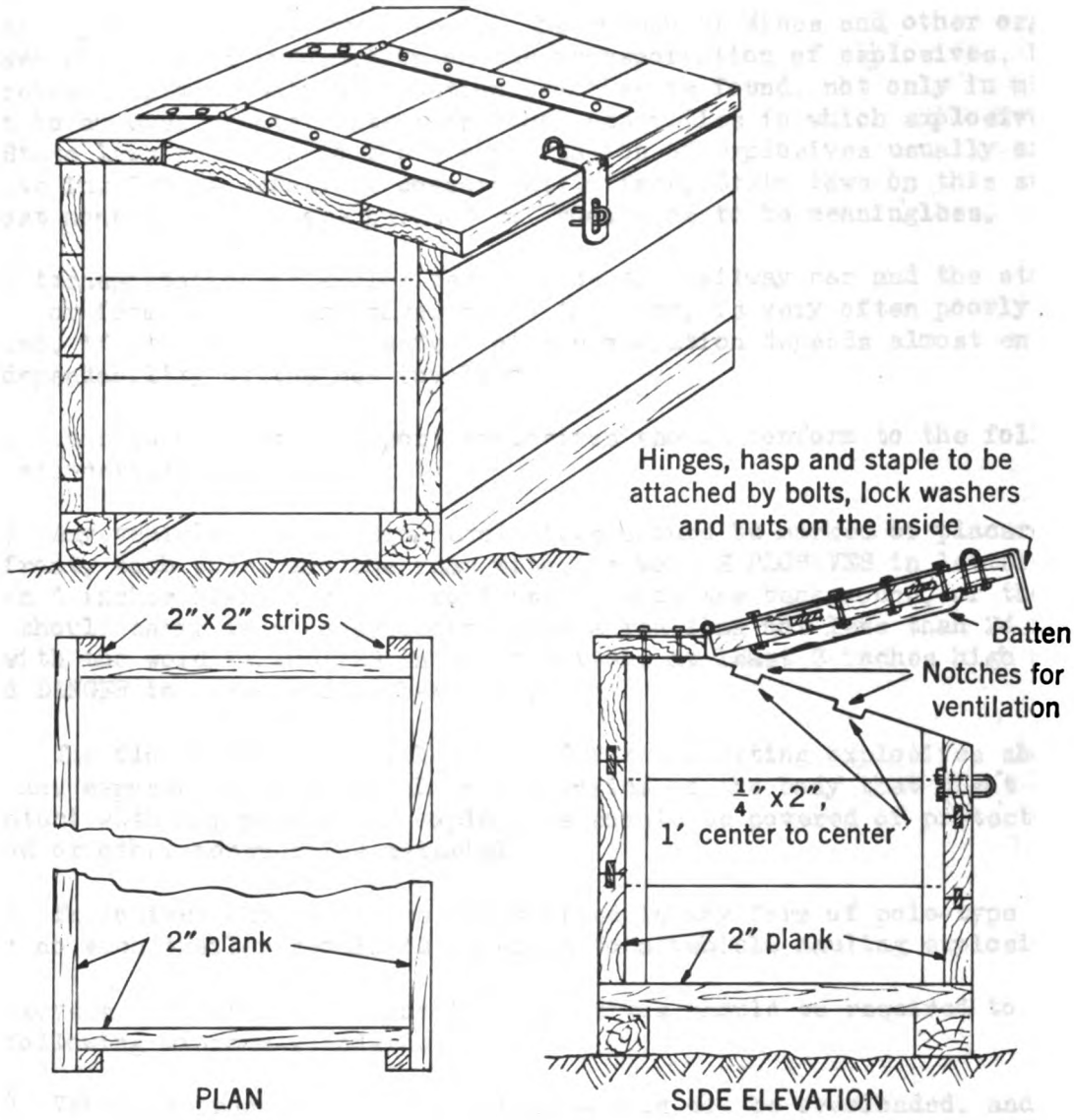

Hinges, hasp and staple to be attached by bolts, lock washers and nuts on the inside
Batten
Notches for ventilation
2" x 2" strips
1/4" x 2", 1' center to center
2" plank
2" plank
PLAN
SIDE ELEVATION

Figure 10. - Box-type magazine for storing small quantities of explosives or those for immediate distribution. Construction: To be built of 2-inch hardwood or 3-inch softwood, well-braced at the corners; lumber to be smooth on the inside of box; no metal to be exposed; and lid or door to be securely locked with at least one lock equivalent to a 5-tumbler jarproof lock.

Generated on 2024-09-19 17:15 GMT / https://hdl.handle.net/2027/osu.32435030643852
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

their own regulations for the transportation of explosives as well as other dangerous articles, and the restrictions of some of the carriers are drastic. The Bureau of Explosives of the American Railway Association has issued much interesting information relating to the transportation of dangerous substances, including explosives of various kinds. The Bureau of Mines and other organizations have also issued information on the transportation of explosives, but much careless explosives-transportation practice is found, not only in mining work but to an even greater extent in other activities in which explosives are used. State laws relative to the transportation of explosives usually are inadequate insofar as safety is concerned; in fact, State laws on this subject are almost nonexistent or are phrased so broadly as to be meaningless.

The transportation of explosives between the railway car and the storage magazine, or from the storage magazine to the user, is very often poorly supervised, if at all, and the safety of the operation depends almost entirely on the dependability of the men involved.

The vehicles used to transport explosives should conform to the following minimum standards:

(a) Any vehicle transporting explosives should be marked or placarded on the front, each side, and the rear with the word EXPLOSIVES in letters not less than 4 inches high in colors contrasting with the background, or the vehicle should carry in a conspicuous place a red flag not less than 24 inches square with the word EXPLOSIVES in white letters at least 3 inches high or the word DANGER in letters 6 inches high.

(b) The floors of all vehicles used for transporting explosives should be tight. Any exposed sparking metal on the inside of the body that might come into contact with any package of explosives should be covered or protected with wood or other nonsparking material.

(c) Explosives should not be transported in any form of pole-type trailer; no such trailer should be attached to a vehicle hauling explosives.

Employees engaged in transporting explosives should be required to conform to the following minimum standards:

(a) Vehicles transporting explosives should not be overloaded, and in no case should the explosives containers be piled higher than the closed sides of the body.

(b) Vehicles transporting explosives should be inspected to determine that the vehicle is in condition for safe transportation of explosives. This inspection would include the brakes, steering mechanism, electric wiring, fuel tank and fuel lines (to be sure that the latter are not leaking), and the body or chasis (to check against accumulations of oil or grease).

(c) Vehicles transporting explosives should be driven only by authorized, competent persons. Persons under the influence of intoxicants or narcotics should not be permitted to operate vehicles transporting explosives.

Generated on 2024-09-19 17:02 GMT / https://hdl.handle.net/2027/osu.32435030643852
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

(d) Packages or containers of explosives should not be thrown, dropped, or otherwise roughly handled while being loaded or unloaded. All explosives should be transported in the original shipping containers or in some other suitable container.

(e) Blasting caps, electric blasting caps, and any form of igniters that are not in the original shipping container should not be hauled in the body of a truck with explosives.

(f) No metal, metal tools, oils, matches, firearms, acid, or inflammable substances should be carried on a vehicle transporting explosives.

(g) Unauthorized persons should not ride on a vehicle transporting explosives.

(h) Smoking or carrying matches should not be permitted on or around a vehicle transporting explosives.

Many commercial companies have additional rules governing their employees while engaged in the transportation of explosives; the above rules are considered to be the minimum requirements.

USE OF EXPLOSIVES

It is not feasible in a publication of this character to discuss safe practices for all types of blasting; the physical conditions and the blasting practice of underground metal mines differ widely from the blasting in coal mines, and both differ from the recognized safe practices in quarry and open-pit work. However, certain needed precautions are common in all types of blasting, and some of these are listed below. They are intended to be of general application; a few important precautions are suggested under the appropriate headings for special types of blasting.

Opening Explosives Containers

(1) Kegs or wooden cases of explosives should not be opened with metallic tools; a wooden wedge and a wooden, rubber, or fiber mallet should be used for this purpose. Metallic slitters may be used for opening fiberboard cases provided the metallic slitter does not come in contact with the metallic fasteners of the case.

(2) Boxes of explosives or kegs of black blasting powder should not be opened inside a magazine.

(3) Boxes containing pellet powder should be opened in the same manner as recommended in (1) for opening dynamite cases. This also applies to free-running or "bag" powder when packed inside wooden cases.

Charging Holes

(4) Blasting should be done with the smallest possible number of persons present.

Generated on 2024-09-19 17:05 GMT / https://hdl.handle.net/2027/osu.32435030643852
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

(5) Explosives that are so hard that a punch cannot be inserted for priming or that are believed to be substandard in any other respect should not be used.

(6) Low-freezing or nonfreezing explosives should always be used. If explosives are believed to be frozen, no attempt should be made to use them or thaw them, but rather the manufacturer should be notified.

(7) All holes for blasting should be checked before attempting to charge explosives. This may be done by inserting an ordinary tamping stick into the hole.

(8) High explosives in small boreholes should be tamped with only enough force to collapse the cartridge. Excess ramming should be avoided. Primer cartridge should never be tamped.

(9) Tamping sticks should be made of wood, with no exposed metal parts. Jointed wooden tamping sticks with exposed couplings of nonsparking material may be used in long holes.

(10) Blasting caps and/or electric blasting caps should be kept separate and apart from other explosives until ready to be used.

(11) The diameters of dynamite cartridges should be small enough so that the cartridges can be pushed or lowered readily into a drill hole. Loose-fitting cartridge maybe compacted by using the tamping stick for this purpose.

MAKING PRIMERS

A primer consists of a cartridge of explosives with some means of firing it attached to the cartridge.

Primers should be made carefully, in accordance with the data published by the makers of explosives, and should satisfy the following general requirements:

(1) The detonator (blasting cap or electric blasting cap) or igniter should be placed in the safest and most effective position in the primer cartridge and should be attached to it in such a manner that it cannot be readily pulled loose from the cartridge.

(2) The detonator should be placed in the primary cartridge of explosives in such a manner that the fuse or leg wires of electric blasting caps are not strained while the hole is being loaded.

(3) The primer assembly of cartridge and detonator should be made so that it can be loaded safely, easily, and in the correct position in the charge.

(4) The primer should be made waterproof if used in wet work. This can be done by sealing the openings in the primer cartridge with soft soap or wax.

Generated on 2024-09-19 17:09 GMT / https://hdl.handle.net/2027/osu.32435030643852
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

Certain definite standards are recognized as increasing the efficiency of the primer in blasting operations, and also definitely decreasing the hazard attending the preparation of the primer and its placement in the charge. Some of these are listed below, but they should be considered as only the minimum requirements:

(1) Dynamite cartridges used for primers should not be slit, as the whole cartridge is necessary to hold the detonator in position and to protect it from abrasion or blows during loading.

(2) Fuse should be cut squarely across with a clean, sharp blade or cutter and seated lightly against the cap charge. The cap should be crimped tightly using only a hand or bench-type crimper. Crimping caps with the teeth, or with a knife, or any tool other than a crimper should be prohibited.

(3) The long axis of the detonator should lie as nearly as possible in line with or parallel to the long axis of the primer cartridge, and in small drill holes the detonator preferably should point toward the bulk of the charge of explosives.

(4) Primers made with fuse and blasting caps should be assembled so that the cap is in the center of the primer cartridge and the fuse has no sharp bends, kinks, or knots. Two recommended methods for assembling this type of primer are shown in figure 11.

(5) Primers made with electric blasting caps should be assembled so that the leg wires will not slip off or permit the cap to be pulled out of the cartridge, and there are no sharp kinks, knots, or overlaps in the wires that may cause the wires to break or to cut into each other through the insulation. Two assembly methods are shown in figure 12.

(6) If detonating fuse is used to fire a column of explosives, the detonating fuse should extend the full length of the column of explosives. The detonating fuse may be lowered to the bottom of the hole by attaching it to the first cartridge loaded.

SAFETY FUSE AND CAP BLASTING

Safety fuse and blasting caps are probably the commonest method in use for detonating explosives; this is particularly true in those instances where only a small number of charges are to be fired or where explosives are seldom used. Electric blasting is supplanting fuse and cap blasting in many mines and quarries, and on construction projects involving large excavations.

Some of the commonly recognized safe practices in fuse blasting, which are minimum standards, are listed below:

(1) Blasters or shot firers should know the burning speed of the fuse that is being used.

(2) The minimum length of fuse to be used should be as required by State law, or as established by the management, but should not be less than 30 inches.

Generated on 2024-09-19 17:02 GMT / https://hdl.handle.net/2027/osu.32435030643852
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

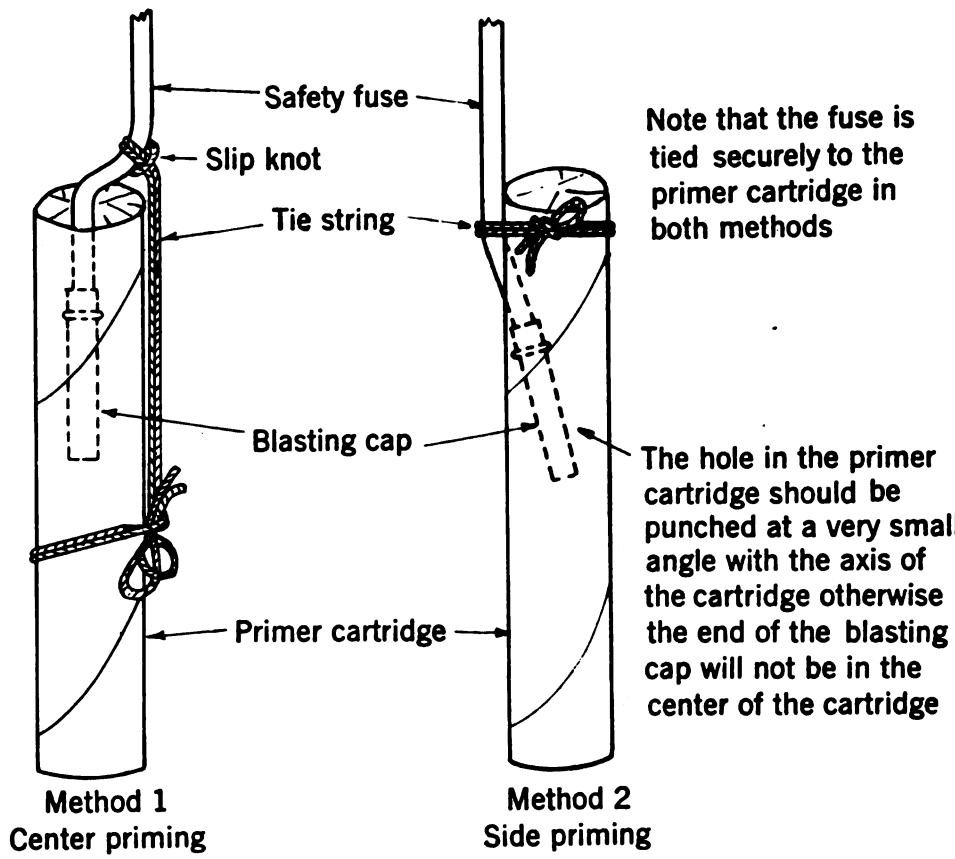

Safety fuse
Slip knot
Tie string
Blasting cap
Primer cartridge
Note that the fuse is tied securely to the primer cartridge in both methods
The hole in the primer cartridge should be punched at a very small angle with the axis of the cartridge otherwise the end of the blasting cap will not be in the center of the cartridge
Method 1
Center priming
Method 2
Side priming

Figure 11. - Recommended methods for making primers with safety fuse and blasting caps.

Generated on 2024-09-19 17:02 GMT / https://hdl.handle.net/2027/osu.32435030643852
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

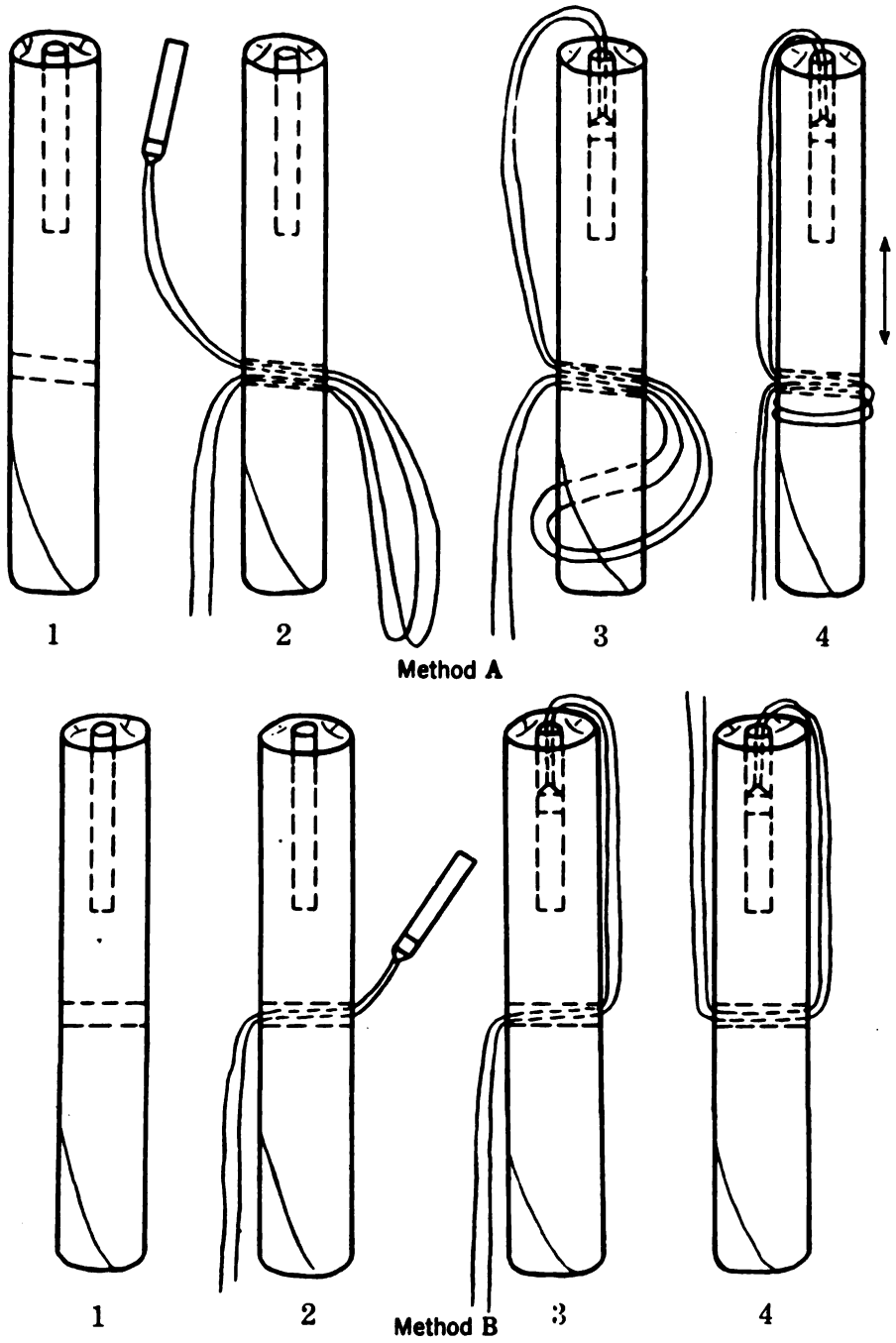


Figure 12. - Recommended methods for making primers with electric blasting caps.

Generated on 2024-09-19 17:15 GMT / https://hdl.handle.net/2027/osu.32435030643852
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

(3) Blasters or shot firers should always use sufficient fuse with an adequate warning signal or system that permits them to reach a safe place before the first hole fires.

(4) The permissible number of fuses to be lighted by a blaster at one time should be determined by the management. Normally, not over 12 fuses should be lighted by each blaster.

(5) An effective lighter should be used in lighting fuse. Several types of good lighters are on the market.

(6) The use of cigarettes, burning paper, or improvised torches for lighting fuse should be prohibited.

(7) Fuse should not be allowed to come in contact with oils, paints, kerosene, gasoline, distillates, or similar solvents.

(8) In wet work, the joint between the fuse and cap should be made waterproof; no substance containing oil should be used for this purpose.

(9) When charges of explosives are to be fired in rotation, a good practice is to dip the uncapped ends of the fuse in a contrasting color of paint or dye (black paint on white fuse for example). The blaster trims only the painted ends of the fuse and thereby eliminates the chance of trimming a fuse twice.

(10) Safety fuse and cap blasting should not be used for firing two or more shots which must detonate simultaneously.

(11) Before an attempt to light the powder train the end of the safety fuse should be freshly cut and clean.

(12) Fuse should never be bent sharply, and care should be taken not to rupture the coverings of the powder train. This may result in sparks being emitted from the damaged place and may cause a premature explosion.

ELECTRIC BLASTING

The improvements made in delay electric blasting devices have increased their use underground because they reduce the number of misfires and permit all blasts to be fired from a safe distance from the face. Electric blasting used in sinking shafts is of particular importance and has been adopted generally.

One of the hazards encountered in electric blasting is "stray" electric currents, which may be strong enough to fire the cap. The stray currents are caused by poor bonding of the rails if electric haulage is used, or by poorly installed electrical equipment, or by other causes.

Some of the safe practices (these are suggested minimum standards only) regarded as standard for electric blasting follow:

Generated on 2024-09-19 17:07 GMT / https://hdl.handle.net/2027/osu.32435030643852
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

(1) Electric blasting caps should be protected from electric currents by shunts or by short-circuiting the cap by twisting together the ends of the leg wires until they are ready to be connected into the blasting circuit.

(2) The leading wires should be kept short-circuited until ready to be connected to the source of current.

(3) Electric blasting caps should be tested individually with a blasting galvanometer before being used. The circuit should be tested with a blasting galvanometer before the shot is fired.

(4) The insulation on all firing lines and/or leading lines should be adequate and in good condition.

(5) Blasting circuits should not be grounded at any point, and bare spots in the wire should not be permitted to touch the ground.

(6) A power circuit used for firing should not be grounded.

(7) When firing from a power circuit, a master switch should be used. It should be locked in the "open" position at all times except when firing. Keys to the master switch should be entrusted only to the person designated to fire the shot.

(8) When firing from a power circuit, one or more safety switches should be placed in the permanent firing line in addition to the master switch used for firing.

(9) As a protection from lightning, an air gap at least 5 feet long should be in both wires of the firing line or between the firing lines and the leading lines.

(10) All switches should be short-circuited in the "off" position but not grounded.

(11) When firing electrically, a two-conductor circuit should be used throughout, that is, the earth, rail, or pipe should never be used as a return circuit.

(12) All blasts detonated with electric blasting caps should be fired from a source of current of ample capacity.

Use of a Blasting Machine or Battery

(13) When firing with a blasting machine, the machine, its detachable handle, or the key for its lock, should be kept in the possession of the person designated to fire it during the connecting up of the blast and until it has been fired.

(14) When firing with a blasting machine or battery, the leading wires should not be connected until immediately before firing and should be disconnected immediately thereafter.

Generated on 2024-09-19 17:01 GMT / https://hdl.handle.net/2027/osu.32435030643852
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

(15) When firing with a blasting machine, the holes should be connected in series or series-parallel, as recommended by the manufacturer.

(16) The number of detonators connected in series should not exceed the rated capacity of the blasting machine.

(17) The blasting machine should be kept in good condition and should be tested at regular intervals.

JOB TRAINING

Very few industrial or mining companies have instituted "job training" for the blasters or other persons working with explosives. In many cases the only requirement for the employment of a blaster is that the applicant knows how to charge explosives and fire them. Emphasis is given other types of work, and employees are given training in an approved method or way of doing particular work they are assigned to do. This training results in increased efficiency and safety.

Blasters and their assistants should be selected with care so that careless men are eliminated. The men chosen should be given job training in blasting, handling, and care of explosives. The new man that is inexperienced should be taught the safe way of doing the work, and the experienced blaster should be given the same training and required to adopt the methods that are recognized as safe practices.

Few, if any, persons knowingly work in such a manner as to endanger their own lives. It is believed that most unsafe blasting practices commonly used are the result of a lack of knowledge of safer methods or that the procedure is dangerous. This can be corrected by instituting job training so that the new man will be taught the safe way of doing work while learning; experienced men will see the dangerous practices they have been using, while at the same time learning the safer methods. Safety rules alone will not accomplish this purpose.

SOME TYPICAL BLASTING ACCIDENTS

Generally, it is difficult to determine the exact causes of blasting accidents, as in many cases the person who is directly responsible is killed and the cause can be determined only by assembling available information, which is often incomplete.

A few of the common causes of blasting accidents are illustrated by using specific accidents that have occurred recently. Accidents from these and similar causes occur year after year. They can be eliminated if the blasters and other persons using or handling explosives are taught safe methods of blasting, and if supervisory officials insist that they be used as a condition of working.

Smelter Blasting Accident

Two men were injured in a blasting accident at a western smelter in 1945 while breaking up the slag. The block of slag was about 14 feet long, 10 feet

Generated on 2024-09-19 17:04 GMT / https://hdl.handle.net/2027/osu.32435030643852
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

high, and 4 feet thick, and at the time of the accident it had been cleared away to within 2 feet of the furnace. Plug holes were drilled with a jack hammer and loaded with a half cartridge of dynamite; holes were fired one at a time.

Five men were working on removing the slag, and the foremen sent three men away while he and an assistant prepared a mud-cap shot on a block of slag. The explosion occurred as the laborer was handing some mud to the foreman. After the accident, the foreman said he was using 10 to 12 inches of fuse but did not remember if he lit it. The foreman was selected to do the blasting because he had used explosives in a metal mine in 1929; the supervisor stated the foreman had been instructed how to do the work, and he had been working satisfactorily before the accident.

Comments

This is another case of using an untrained blaster. A fuse 10 to 12 inches long is too short to be used in any kind of blasting. The standard burning rates of fuse are 30 or 40 seconds per foot, which in this case allowed the blaster 30 seconds or less to reach a safe place. The blaster was evidently inexperienced and improperly instructed in the safe handling of explosives.

Failure to Give Warning Causes an Accident

A clay mine in Pennsylvania had a fatal blasting accident in 1944 caused by the failure of the miner to make certain all persons were in safe places before firing the blast.

The mine is worked by the room-and-pillar method, and the shots are fired electrically. The blasting cable is supported on props or along the side of the room and is not rolled up when not in use. The company supplies blasting machines that serve several working places.

The foreman and a trackman entered the room to measure the yardage and were writing the results when the explosion occurred; the trackman was killed.

The miner had charged the drill holes, connected the leg wires of the electric blasting cap to the blasting cable, and then had gone to secure the blasting machine from a neighboring room. The miner connected the blasting machine to the blasting cable and fired the shot without making certain that anyone had entered the working place; the accident resulted.

Comments

A blaster trained in safe methods of blasting would not have connected the electric blasting caps to the blasting cable until ready to fire the shot, and would have made certain that everyone was in a safe place before firing.

Accident Caused by Loading a "Hot" Drill Hole

A premature explosion occurred in a California quarry in 1944 as a result of loading a drill hole too soon after springing. The blaster died as a result of the injuries received.

Generated on 2024-09-19 17:14 GMT / https://hdl.handle.net/2027/osu.32435030643852
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

A drill hole inclined about 75° from the horizontal was sprung and after waiting 20 minutes the blaster started to load the hole. The primer cartridge and one other cartridge of dynamite were loaded, and the blaster was pouring black blasting powder into the hole when the explosion occurred. The investigators believed the cause of the explosion to be the result of loading explosives in a hole that was still hot from the blast of the springing charge.

Comments

Drill holes that are sprung as chambered to receive the final charge of explosives should be allowed ample time to cool before more explosives are loaded, preferably over night, but at least 2 hours. A practical method of determining positively when a drill hole has cooled enough to load explosives has not been devised; some companies are reported to use thermometers and some blasters stick metal rods into the hole and withdraw it when the rod has been heated to the temperature of the chamber. The safest practice is to allow the hole to cool over night when it is feasible to do so.

Two Accidents While Capping Fuse

Two accidents occurred within 10 days in the same mine while miners were inserting safety fuse in blasting caps. In both accidents each man lost the thumb and three fingers of the left hand.

A miner obtained two blasting caps from a cache on some timbers and the accident occurred while the miner was placing the cap on the fuse preparatory to crimping it. It is believed some foreign substance was in the cap, and when the fuse was inserted (and probably twisted), the cap exploded.

The second accident victim stated that the fuse wrapping was loose and that he had difficulty in placing the fuse in the cap. The victim pushed hard on the cap, twisting it at the same time, and the explosion resulted. The miner had carried this blasting cap with three other caps loose in his pocket from the previous day, and it is probable that dirt or other foreign material was in the cap.

Comments

Forcing fuse into the barrel of a blasting cap, or twisting the fuse after it is in contact with the explosive at the end of a cap, is inviting an explosion; for many years the manufacturers of blasting caps have warned against this practice. One of these accident victims had worked in the mines for 30 years and the other about 2 years; this emphasizes the necessity of instructing experienced blasters, as well as new men, in the hazards attending the use of explosives and in the safe ways of handling and using explosives. Blasting caps should not be carried loose in the clothing nor allowed to lie around loose; caps should be stored in separate containers apart from other explosives.

Smoking Probably Causes an Accident

A blaster and his helper were preparing a shot on a rock ledge in a novaculite quarry in Arkansas. The hole, 4 feet deep, was being loaded with 1½ cartridges of pellet powder, size 1-3/4 by 8 inches, and was to be detonated

Generated on 2024-09-19 17:15 GMT / https://hdl.handle.net/2027/osu.32435030643852
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

with a blasting cap and fuse. A cartridge of the pellet powder was placed in the hole and was being tamped with the wooden handle of a shovel when the explosion occurred; the blaster received injuries that resulted in his death.

The helper stated the paper wrapping had been removed from the pellet powder, and some of the powder spilled around the collar of the hole. The blaster was smoking while loading the hole. It is not definitely known whether a spark from the cigarette ignited the explosive, whether the steel blade of the shovel struck a rock causing a spark which ignited the explosive, or whether a match fell from the blaster's pocket and caused the ignition, as matches were found in his pocket.

Comments

The blaster was known to be careless in handling of explosives, although he had had 20 years experience. All of the possible causes of the ignition are unsafe practices in handling explosives and show lack of training. Smoking or carrying matches while handling or using explosives is a dangerous practice, and the use of tamping sticks with any metal parts is unsafe.

Shaft Accident Caused by Using Short Fuse

Two men were killed in a blasting accident in a shaft at a mine in 1943 because they underestimated or more probably were not acquainted with the burning rate of fuse.

The shaft was 350 feet deep at the time of the accident, and the nearest safe refuge at blasting time was the 300-foot level. The men climbed to their refuge after lighting the fuse to blast a shaft round. The shaft work had been in progress about 3 months preceding the accident, and an average of two rounds was blasted each week. The explosives were detonated with caps and fuse, always a dangerous method in shaft sinking.

The shaft foreman stated that 19 holes had been drilled and each one loaded with 4 sticks of dynamite. Normally, 6-foot fuse was used. He said, "This meant 6 minutes would be used to set off the dynamite, as the fuse burns a foot a minute. After lighting the 19 fuses, the miners climbed up the ladder to the safety station 50 feet above." On the day of the accident the miners had trouble in lighting the fuse, and the foreman who was waiting about 8 feet up the ladder timing the fuse observed that 4 minutes had elapsed so shouted to the men to get out as only 2 minutes remained; one of the miners replied there was plenty of time and to wait for him. The foreman shouted several times for the men to get out and started up the ladder, but the miners did not follow. The shots exploded and the men were killed.

Comments

The blasting practice in this shaft is poorly planned; using 6-foot fuse when 19 holes are to be lighted and requiring men to climb 50 feet to safety are inexcusable. The foreman said that he held a watch, and it was agreed that all should retreat when 4 minutes had elapsed after the first fuse had been spit, under the asumption that the fuse burns at a rate of a foot a minute;

Generated on 2024-09-19 17:15 GMT / https://hdl.handle.net/2027/osu.32435030643852
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

hence after 4 minutes elapsed from the first spitting a "cushion" of 2 minutes would remain to permit escape. As a matter of fact, present-day fuse usually burns at a rate of about 40 seconds per foot of fuse; therefore, at the end of 4 minutes the flame in the first fuse that had been spit should have traveled 6 feet (240 ÷ 40 = 6). The fuse evidently performed in the way it should, and these men were the victims of a lack of knowledge of the characteristics of the fuse used.

Unquestionably many old timers were told that the burning speed of fuse is (or was) 1 foot per minute, and the men at this particular mine still held that idea. It would appear that some educational work is needed to dispel the idea that a "foot-a-minute" is the burning speed.

The burning rate of fuse should be determined frequently and should be posted prominently throughout the mine.

Electric blasting is generally a much safer method to use in shaft work, although it, too, is anything but foolproof.

CONCLUSIONS

Explosives are inherently dangerous; they are designed to be violent, disruptive, and destructive and only by recognizing this fact can their use be made reasonably safe. Various groups have issued many publications that emphasize the necessity of adopting procedures in storing, handling, transporting, and using explosives that tend to minimize the danger, but it is only by constant vigilance of the supervisor and by extreme care of the user that accidents from explosives can be avoided.

Many safety standards have been adopted as the result of an accidental explosion that disclosed a hazard that had been overlooked. Some experienced blasters have been killed or injured while using explosives in exactly the same way they had been doing for years - only the conditions that would cause the explosion did not occur until the accident happened. Practices in handling explosives that will cause an accident in one locality may cause an explosion in another place under the same conditions.

Blasters are seldom given "job training" in blasting and taught the recognized safe practices in handling and using explosives; their training, all too frequently, has been to work with another blaster until they learn the ways and practices of using explosives from him. In this way the unsafe, dangerous practices of one blaster are carried forward to the new men they are training.

Many accidents result from the use of explosives by persons untrained in their use, who do not realize the hazards involved and do not know that recognized safe practices have been established. This is particularly true in those industries and occupations that use explosives infrequently, such as agriculture, forest workers, and workers in areas remote from mining operations where explosives are used.

Generated on 2024-09-19 17:04 GMT / https://hdl.handle.net/2027/osu.32435030643852
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

The safe practices outlined in this publication are expected to help make the storage, handling, and use of explosives less hazardous to persons and property. They represent minimum standards for reasonable safety in this work but do not by any means cover all the known hazards. However, if the practices recommended are adopted and used, the blasters will work far more safely than many do at present, and accidents caused by the misuse of explosives will be reduced.

Procedures with regard to the handling of explosives by commercial users, including those engaged in the mining and allied industries, are not well-coordinated insofar as safety is concerned. At least one major reform should be instituted, namely, the establishment of some effective means of certification, possibly by some Government agency, of all persons who handle explosives, especially those who actually use them.

BIBLIOGRAPHY

1. BLASTERS' HANDBOOK. E. I. Du Pont de Nemours & Co., Wilmington, Del., 1942, 339 pp.
2. PRIMACORD BICKFORD DETONATING FUSE. Ensign-Bickford Co., Simsbury, Conn.
3. RULES FOR HANDLING, STORING, DELIVERING, AND SHIPPING EXPLOSIVES. Institute of Makers of Explosives, New York.
4. SAFETY IN THE HANDLING AND USE OF EXPLOSIVES. Institute of Makers of Explosives, New York, Pamph. 17, 1940.
5. STANDARDS FOR SAFETY IN QUARRY OPERATIONS. Cement and Quarry Section, National Safety Council, Chicago, Ill., 1944.

Bureau of Mines Publications

Inf. Circ. 7115. Cars for Transporting Explosives, by C. W. Owings. 1940. 6 pp.

Inf. Circ. 7191. Prevention of Premature Shots During Springing of Deep Drill Holes in Quarries and Open-Pit Workings, by D. Harrington and C. W. Owings. 1941. 8 pp.

Inf. Circ. 7259. Accidents Due to Misuse of Explosives, by D. Harrington and J. H. East, Jr. 1943. 14 pp.

Inf. Circ. 7275. Accidents to Children from Blasting Caps, by D. Harrington and R. G. Warncke. 1944. 13 pp.

Inf. Circ. 7281. The Burning Rate of Fuse, by D. Harrington and R. G. Warncke. 1944. 10 pp.

Inf. Circ. 7296. Blasting Hazards in Strip Mines Adjacent to Underground Workings, by J. J. Forbes and H. F. Weaver. 1944. 5 pp.

Inf. Circ. 7307. Surface Storage of Explosives, by D. Harrington and R. G. Warncke. 1945. 16 pp.

Inf. Circ. 7335. Destruction of Damaged, Deteriorated, or Unwanted Commercial Explosives, by R. D. Leitch and P. R. Moyer. 1945. 6 pp.

Miners' Circ. 54. Prevention of Explosives Accidents in Metal Mines. Metal-Mine Accident-Prevention Course--Section 4. 1945. 80 pp. 20 cents.

Tech. Paper 567. Preventing Accidents by the Proper Use of Permissible Explosives, by D. Harrington and S. P. Howell. 1936. 43 pp. 10 cents.

Generated on 2024-09-19 17:15 GMT / https://hdl.handle.net/2027/osu.32435030643852
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY